Geological Society, London, Engineering Geology Special Publications

Disasters are not natural: risk management, a tool for development

S. Mora

Geological Society, London, Engineering Geology Special Publications 2009; v. 22; p. 101-112
doi:10.1144/EGSP22.7

Disasters are not natural: risk management, a tool for development

S. Mora

Humberto 1mo 844, PB-A, Buenos Aires, C1103ACR Capital Federal, Argentina
(e-mail: sergio.moracastro@gmail.com)

Abstract: Risk management is a policy promoting the identification, analysis and quantification of the probability of damage that a natural hazard might cause, considering the vulnerability of the human environment and the ways to prevent and mitigate the losses in advance. In Latin America and the Caribbean (LAC) available information about causes and consequences of risk is scarce and barely matches the needs of project engineers and decision-makers. Average annual losses caused by major and 'minor' hazards (the latter usually not included in the statistics) amount to a large share of the development effort. Disasters provide evidence of the vulnerability of the countries, have a severe impact on the economic performance and social well-being through the loss of infrastructure, agricultural capacity, basic services, housing and environmental deterioration, and affect the quality of life of the poorest sectors of the population. Therefore, vulnerability is an economic problem with deep social roots. In LAC, the circumstances influencing the *ex ante* decision-making processes have not been favourable to prevention. Governments still reinforce reactive institutions, which are usually centralized. Delegation of tasks and responsibility to national planning entities, local governments and communities trails behind. Typically, local communities bear the brunt of the losses and do not participate in defining the 'acceptable' levels of risk. Therefore, it is evident that there is no such a thing as a 'natural disaster'. The inclusion and adoption in investment projects of risk management criteria supported by engineering geology should start by increasing awareness, understanding and modelling of natural hazards, reducing vulnerability, and increasing social, environmental and economic resilience. This paper analyses practices based on experiences in LAC and proposes proactive risk management criteria.

Risk management is inspired by the anticipated reduction of losses (human and material) that natural hazards may cause in the future. It is a policy by means of which the possibility of losses is identified, analysed and quantified, and at the same time measures of prevention, mitigation, reduction and retention or transfer of risk can be proposed and executed.

Despite the overwhelming evidence that disasters hinder development in societies, the challenges and options for confronting their causes and consequences and the establishment of adequate risk reduction strategies lag behind or do not attain a level of priority on the agenda of decision-makers: risk management is still regarded as a cost, not as an investment. Until now, it has not been possible to consolidate political and managerial cultures incorporating risk management throughout decision-making processes for public–private investment and planning. It becomes clear that the very first steps, centred upon reinforcing education, both formal and informal, leading to the necessary change of paradigm and public policies are still embryonic, and only a few outstanding efforts can be identified as effective.

Our societies need urgent, sustainable and effective actions. In absolute numbers, the costs of losses attributable to disasters in Latin America and the Caribbean (LAC) have been estimated at around US$105 billion (approximately US$3.5 billion per year) since 1975. The years with the highest losses have been 1983 (floods in Argentina, Bolivia, Brazil and Peru, and earthquakes in Chile and Colombia), 1985 (earthquake in Mexico City), 1998 (floods, landslides and torrential debris flows associated with hurricanes Georges and Mitch in Central America and the Caribbean). During the same period close to 275 000 human deaths have occurred and 151 million people were affected (Mora 1995, 2003; CEPAL 1996, 1998, 2000, 2001*a*, *b*). These statistics reflect only the impact of 'major' natural hazards. If the effect of 'minor' hazards is accounted for, the aggregated value is still higher (BID 2000; Cardona 2006), as follows.

(1) Damage and losses related to El Niño (1997–1998) have been estimated at a minimum of US$15 billion.
(2) Hurricane Georges (1998) affected five Caribbean countries; in the Dominican Republic it caused US$2.3 billion in damage.
(3) Landslides and torrential debris flows in Venezuela (December 1999) left losses of around US$3.5 billion and 20 000–50 000 fatalities.
(4) Since 2000 new events have aggravated the situation: floods in Chiapas (Mexico), Táchira (Venezuela), Santa Fe (Argentina), Brazil, Bolivia, El Salvador, Chile, Colombia, Nicaragua, the Dominican Republic and Haiti; earthquakes in Pereira (Colombia) and El Salvador; volcanic eruptions in Ecuador, Nicaragua, Chile, El Salvador and Guatemala; torrential debris flows in Peru, the Dominican Republic, Venezuela and Haiti; and landslides in Costa Rica, Venezuela, Guatemala, Brazil, Ecuador, Peru, Colombia and Bolivia, among others (Figs 1–3).

From: Culshaw, M. G., Reeves, H. J., Jefferson, I. & Spink, T. W. (eds) *Engineering Geology for Tomorrow's Cities.* Geological Society, London, Engineering Geology Special Publications, **22**, 101–112.
DOI: 10.1144/EGSP22.7 0267-9914/09/$15.00

Fig. 1. Santa Tecla landslide, El Salvador, triggered by the January 2001 earthquake. A relatively small landslide (40 000 m^3) but linked with a high vulnerability, caused the death of 300 people and considerable material losses.

Available information on the causes, variables and consequences of risk derived from natural hazards and human vulnerability is deficient, insufficient and scarcely matches the needs of researchers and decision-makers. Public policies are not yet based on adequate sustainable community and regional organizations and management, and reflect the principles of 'command and control' instead of 'persuasion and incentive'. Therefore, disasters are evidence of the material effects of vulnerability of the population, cities and countries facing natural hazards, and the severe impact on their economic performance and social well-being. Losses of capital stock, infrastructure, services and production reach significant proportions when natural hazards damage roads, irrigation, electrical generation and transmission, education facilities, aqueducts, sanitation, drainage, public health, housing and natural services. These losses affect the economy and quality of life mainly of the poorest segments of the population, who suffer from a reduction of access to basic social services, productivity and markets.

Fig. 2. Adobe houses destroyed by the 2001 earthquake in El Salvador. This building system, although relatively inexpensive, has always proven to be unsafe and vulnerable to earthquakes.

Fig. 3. Torrential debris flows affected the northern littoral of Venezuela (December 1999– February 2005). Beach resorts and coastal cities (e.g. Caraballeda, Carmen de Uria, Los Corales, Macuto) are built on piedmont fluvio-marine alluvial fan-deltas. Photograph by D. Salcedo (1999), with permission.

Efforts have not been sufficient: factors of failure

In LAC, circumstances influencing decision-making processes have not been favourable to risk management. Even though some progress has been accomplished during the past few years, emphasis and political priority is still given to civil defence structures: mitigation, emergency and disaster response efforts. Awareness in advance of natural hazards and vulnerability, *ex ante* prevention, decentralized and local risk management, and financial protection based on retention–transfer lag dramatically behind. As a consequence, the impact of natural hazards almost invariably falls onto the population, which in a large majority of cases did not have the opportunity to participate in, nor were informed about, the characterization of the level of risk to which they were exposed and/or the options to reduce it.

Although we may be far from fully understanding the natural laws governing natural hazards and disasters, it is possible to state that the scientific community should already be in a position to influence decision-making processes. However, scientists are capable of analysing, to a sufficiently high degree of accuracy, such aspects as the causes and potential consequences of hazards (seismic, volcanic, cyclonic, droughts, landslides, floods, climate variability and change), vulnerability (economic, physical, structural, psycho-social, environmental, institutional), and the effectiveness of *ex post* capacities (response, rescue, relief, rehabilitation). Nevertheless, it is legitimate to ask why losses keep steadily rising despite the efforts, and our cities continue to expand somewhat chaotically. Even where so-called ‘planned’ expansion takes place, environmental degradation and uncontrolled immigration or growth occur and, thus, an unsustainable model of development promotes significant increases in vulnerability.

From all these factors, it is possible to conclude that society faces a paradox: on the one hand, it creates situations aggravating the effect of natural hazards (i.e. vulnerability) and, on the other, tries to mitigate the consequences using technology at a very high cost and, often, too late, while taking refuge in an indulgence of considering itself a victim (Fig. 4). As it is, vulnerability is essentially an economic problem with very deep social roots and, therefore, a hindrance to development.

Considering these poor results, it seems reasonable to ask why the historical memory is lacking and why risk management performance is so deficient in many countries that are so frequently and intensely affected by natural hazards. Perhaps a part of the answer lies in the fact that, so far, the scientific community has been incapable of generating awareness in decision-makers, of providing them with tools to address their political arguments in a convincing way towards establishing public policies, and in incorporating risk management in public–private investments and planning.


Agua traicionera

Fig. 4. Fatalistic newspaper illustration showing ‘Nature’ as the cause of our own creation of vulnerability (‘Treacherous water’; *La Nación*, Costa Rica, 1997).

Disasters, deaths and costs

Undoubtedly, in the LAC region the frequency with which disasters occur shows a clear rising trend. Year after year the combination of the effect of natural hazards with social, economic and environmental realities leads to an increasing number of disasters. As a consequence, the elevated toll of human, infrastructural and socio-economic losses hinders opportunities for development and deepens the fragility and impoverishment of the population, particularly in marginal urban areas, which are already the poorest, thus forming vicious circles of cause and effect: vulnerability → social + environmental degradation → disasters → more vulnerability, and so on.

This scenario does not necessarily mean that the intensity or the recurrence of natural processes has increased, despite the ever-growing information available and the debate on the effects of climate change (Figs 5–7). The growth rate is not necessarily higher than in the rest of the world. However, the increase in the frequency of disasters seems, instead, to be associated with the fact that the threshold required by natural hazards to attain a damage potential is lower (Charvériat 2000; Mora & Barrios 2000).

It is worth mentioning here the case of hurricane Georges (September 1998), where previous human intervention in the environment and natural resources (i.e. degradation, chaotic urbanization) contributed to amplification of the degree of exposure and fragility of the population. It was estimated that over 50% of the economic impact resulted from an inadequate land use practices (CEPAL 1998; Mora & Lücke 1998; Mora 2003). Incorrect location, design, construction quality and lack of appropriate maintenance were the second cause (35%) of losses.

At present, it is clear that risk management is not: (1) an integral part of the discourse or the actions of political leaders beyond isolated, rhetorical exposure to the media during the initial ‘post-disaster’ actions; (2) integrated into

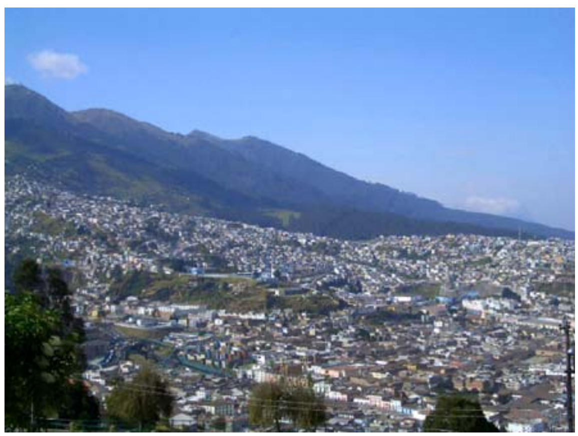

Fig. 5. The city of Quito, Ecuador, built at the foothills of Pichincha volcano, has already been affected by eruptive ash-falls (July 2005).

Fig. 6. Effects of liquefaction generated by the Telire–Limón earthquake, Costa Rica ($M_w = 7.6$; 1991); San José–Caribbean coast highway.

national and sectoral policies; (3) entirely understood and adopted by the population and public and private investors; (4) integrated into understanding and knowledge of the values lost and of the interest in mitigating these losses, to reduce hindrance to development processes; (5) considered a long-term investment (it is considered to be a cost); (6) provided with adequate tools to aid decision-makers in identifying the advantages of financial protection and risk retention or transfer tools. On the present trend, risk management will not move forward unless a change takes place in the scientific linkage with political understanding, inducing a solution to the present weaknesses and the lack of the following: (1) adequate knowledge of hazards, vulnerability and the tools to reduce risk; (2) effective, consistent public policies and strategies on risk management, and convincing arguments, based upon scientific and engineering data; (3) legal and institutional criteria based upon persuasion and incentives, leading to financial protection of public–private investments by applying risk retention or transfer principles; (4) incorporation in planning, development strategies and education (both formal and informal).

Fig. 7. Urban expansion in Port-au-Prince, Haiti. Settlements develop at the foothills of slopes showing evidence of recent instability and mass movements (landslides and rockfalls, 2003).

Elements for a risk management strategy

The first step that the scientific community should take is learning the language of political decision-makers and private investors. The goals of this pursuit can be to: (1) orientate and influence decision-makers to incorporate risk management in national development planning, public policies and investment processes; (2) foster interest in, and awareness and appropriation of the topic, so that national leaders and entrepreneurs will commit themselves to the actions of risk management. The means of achieving such a strategy should take into account the following: (1) understanding the idiosyncrasy of decision-makers and adapting the technical content of information and action proposals; (2) presenting the message in an attractive way, making it profitable from the managerial and political standpoints; (3) highlighting the advantages of preventive vision, as well as the responsibilities acquired by inaction; (4) making clear that it will not be acceptable to plead ignorance, considering the present information available; (5) underlining the fact that development and reduction of vulnerability are two inseparable processes.

Risk, hazards and vulnerability

Natural hazards derive from the damaging potential or a combination of: (1) internal geodynamics (seismicity and volcanism); (2) hydro-meteorology, both global and local processes (cyclones, drought, El Niño, intense rainfall); (3) external geodynamics (mass movements such as landslides, intensive erosion, torrential debris flows) (Fig. 8).

Natural hazards (H) can thus be defined as the probability that an event becomes so intense (a) within time and space frames that it produces significant damage (d). Vulnerability (V) is the probability that, according to the intensity of the natural event, damage might occur as a function of the degrees of exposure and fragility of the elements involved. Risk (R) therefore is the combined probability (convolution, *) that a hazard might cause significant damage, according to the following relationship:

$$\int_h p(H)\mathrm{d}a_* \int_d p(V)\mathrm{d}a = \int_{h,d} p(R)\mathrm{d}a$$

(see Fig. 9).

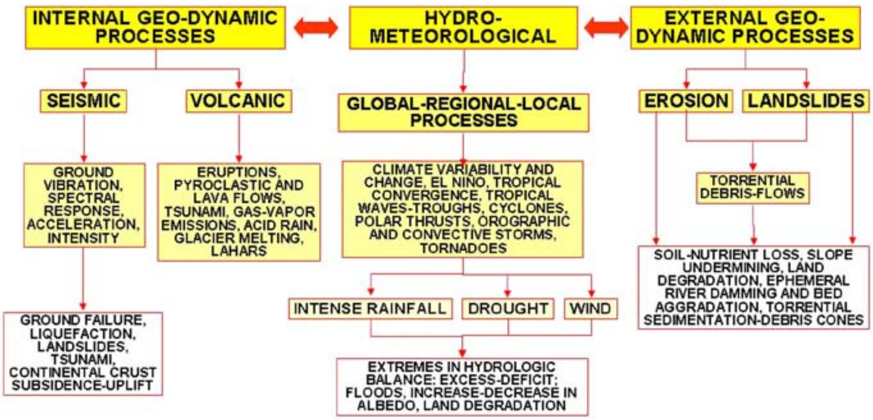

Fig. 8. Simplified schematic classification of natural hazards and their secondary effects, according to their origin.

Therefore, risk management is defined as the process of identifying, analysing and quantifying the probability of loss and its secondary effects derived from the impact of natural hazards, as well as feasible social, economic and environmental preventive, corrective and reductive measures (see Table 1). An integrated vision of risk management focuses on *ex ante* policies and actions depending upon (1) the identification, analysis and quantification of risk, (2) the formulation and application of prevention, reduction and mitigation of the causes, (3) financial, social and environmental protection by retaining or transferring criteria, and (4) the execution of subsequent awareness, preparedness, response, rehabilitation and reconstruction protocols and procedures. However, although substantial advances in knowledge about natural hazards and the associated vulnerability factors have been made during recent decades, the availability of accurate and accessible information is still insufficient and scarcely meets the requirements of risk evaluators and decision-makers (Mora 1995; Mora & Barrios 2000).

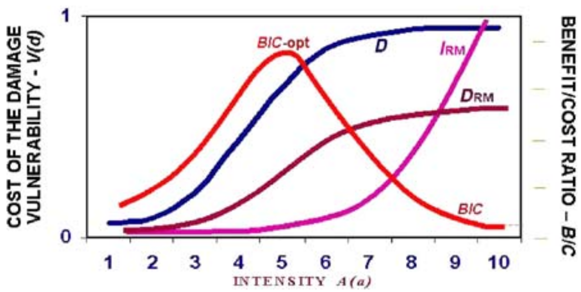

Fig. 9. Benefit/cost (B/C) ratio defined as a function of damage expected without risk management (D), reduced by applying risk management (D_{RM}) and the investment involved (I_{RM}).

The relationship between hazards and vulnerability allows the use of risk management as a tool for identifying, analysing and quantifying the damage potential of hazards and the actions to be undertaken to reduce vulnerability. The simplified schematic model represented in Figure 9 shows an original accumulating damage curve D (without risk management) reduced to a lesser damage distribution D_{RM} once risk management practices have been applied and thus expressing the reduction of damage $D - D_{\mathrm{RM}} = RM$. The amount of investment required to achieve such a reduction (I_{RM}) depends upon the type of hazard and vulnerability involved, and might strongly rise once intense hazards and fragile elements combine. Benefit/cost (B/C_{OPT}) estimations allow the finding of optimal levels of investment and the rational borders of retention or transfer of risk. The net benefit of risk management B_{RM} is defined as the difference between RM and I_{RM}:

$$
\begin{aligned}
B_{\mathrm{RM}} &= RM - I_{\mathrm{RM}} \\
B_{\mathrm{RM}} &= (D - D_{\mathrm{RM}}) - I_{\mathrm{RM}}.
\end{aligned}
$$

The benefit/cost ratio B/C can be defined through

$$
\begin{aligned}
B/C &= B_{\mathrm{RM}}/I_{\mathrm{RM}} \\
B/C &= (RM - I_{\mathrm{RM}})/I_{\mathrm{RM}} \\
B/C &= [(D - D_{\mathrm{RM}}) - I_{\mathrm{RM}}]/I_{\mathrm{RM}} \\
B/C &= [(D - D_{\mathrm{RM}})/I_{\mathrm{RM}}] - 1.
\end{aligned}
$$

If B/C is plotted as in Figure 9, it might be possible to identify or select an optimal point (B/C_{OPT}) limiting profitable investments in risk retention (mitigation) or transfer (financial protection, insurance).

Table 1. *Objective of a risk management policy*

Reducing the effect of disasters (economic, social, human, environmental and material losses) by:
introducing and socializing prevention within the culture through formal and informal education;
accepting a cohabitation with natural hazards, according to a rational level of 'acceptable' risk;
reducing risk by reducing vulnerability;
fostering risk management throughout national, regional, local and sectoral development planning;
developing effective local capacities for preparedness, response and the recovery of quality of life after a disaster in rapid, efficient and safe ways;
influencing decision-makers in development planning by addressing risk management as an investment not as a cost, and as an inevitable part of development

What really is vulnerability?

There are several definitions of vulnerability. It could be summarized as 'the exposure, fragility and deterioration of elements and aspects generating and improving social existence'. It is made up of five measurable factors: (1) the degree of exposure to hazards; (2) the degree of fragility (inverse of resilience) of the elements exposed; (3) the social–economic value of possible losses; (4) the alterations to the human quality of life (deaths, injuries, trauma, forceful displacements, etc.); (5) the impact on environmental–natural goods, services and functions. Vulnerability is also the replacement of adequate design by another of lesser quality; a liability of very deep social roots, which is made worse by a very low threshold of 'accepted risk' (Fig. 10). It also can be seen as a deficiency of the development model adopted. The problem tree in Figure 11 illustrates the cause–effect relationships in the aggravation of vulnerability.

Another way to look at vulnerability regards it as a temporary natural liability, an apparent saving in prevention obtained by inadequate investments in design, and insufficient regard for regulations, quality control and environmental management. In other words, there is a replacement of all the former by 'accepted risk' ('this will never happen to me'). Under this premise, as long as there is no disaster nobody pays the subsidy, but when a disaster occurs the saving becomes only apparent.

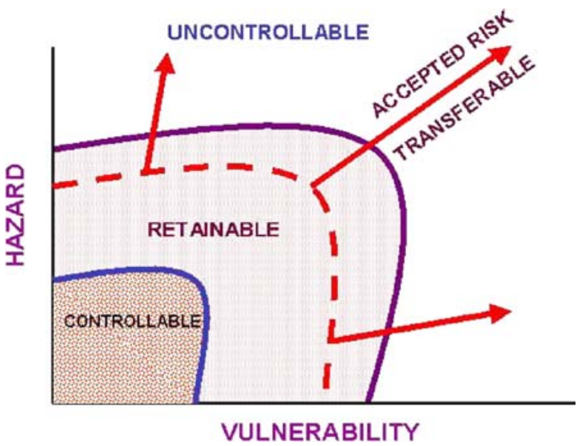

Fig. 10. Categories, degrees and types of risk defined by their levels of hazard, vulnerability and benefit/cost relationship.

Reducing vulnerability by development planning

Vulnerability has significantly increased during recent decades as a consequence of demographic growth, chaotic urban and infrastructural expansion, environmental degradation and the uncontrolled increase of poverty and marginality. Hazards and vulnerability have not yet been considered fully; inadequate land-use practices and the non-existence or non-application of building codes further aggravate the situation. At present, most of the investment effort in LAC lacks sufficient risk reduction components. Because risk management is not a prevailing trait of communities, political decision-makers or managers, it is frequently considered to be a cost rather than an investment. The difference between 'accepted' and 'acceptable' risk is not always well understood. The absence of public policies and appropriate measures promotes diversion from adequate design, location, quality control, construction and maintenance (Figs 12–16). It has to be admitted that poor knowledge of risk and the possibilities for its reduction is a factor in determining the magnitude of the damage that will occur.

Risk management focuses primarily on *ex ante* measures such as: (1) identification of the causes and consequences of risk; (2) formulation and application of prevention and mitigation actions, (3) financial protection through transfer and retention of risk; (4) preparedness to cope with emergencies; (5) rehabilitation and reconstruction procedures aimed at reducing further vulnerability. Efforts to foster these measures must include: creation of policies, regulatory frameworks and institutional protocols to incorporate all stakeholders into reducing risk; improvement in information on hazards; identification of social, economic and environmental sources of vulnerability during planning, design,

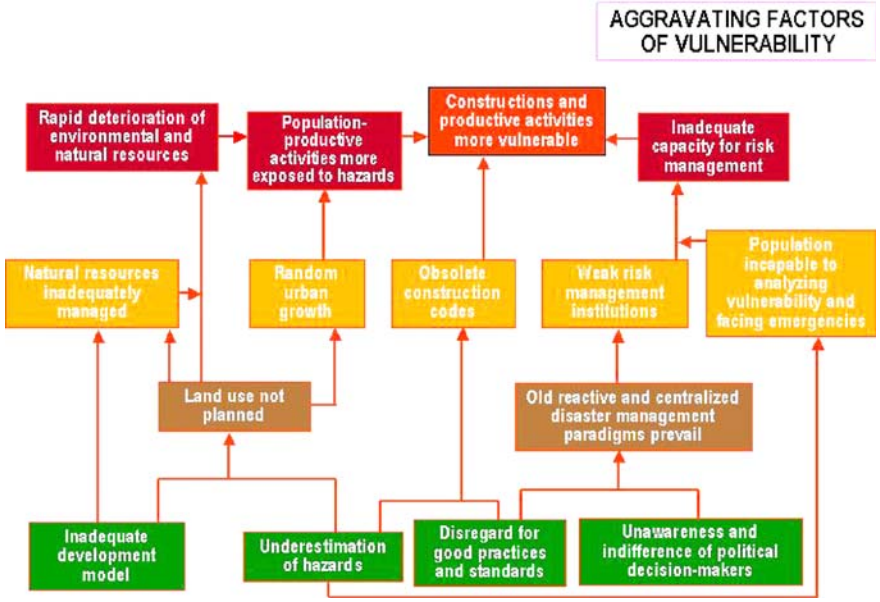

Fig. 11. Problem tree illustrating common aggravating factors of vulnerability in Latin America and the Caribbean.

choice of location and implementation of projects; definition of acceptable risk levels; design and establishment of indicators to model and monitor impacts and *ex ante* menus of prevention and mitigation measures.

A risk management policy fosters and integrates strategically balanced processes of development, reinforces a reduction of vulnerability and promotes adequate criteria for retention or transfer of risk through financial protection tools. Additionally, it supports synergistic institutional frameworks, and decentralized, participative and sufficient political and financial criteria capable of helping decision-makers to choose priorities through transparent evaluations and according to the fundamental needs of national planning. Sustainable conceptual and operative platforms for risk management can be linked to environmental management and engineering geological tools, as follows: (1) instruments for a financial strategy, budgetary allocations, institutional and legal frameworks (e.g. laws, by-laws, regulations, standards, codes) with an appropriate distribution of authority and responsibilities; (2) macro- and micro-zoning of hazards and vulnerability, based upon spatial models and

Fig. 12. Urban densification, incorrect use of space, and questionable quality of housing and infrastructure in El Alto and La Paz, Bolivia (2005).

Fig. 13. House affected by a landslide caused by a public road-cut. Kantutani, La Paz, Bolivia (2004).

Fig. 14. Complex and high-cost retaining wall design to reduce the vulnerability of a mansion in La Florida, La Paz, Bolivia (2005).

Fig. 16. Slope in La Paz, Bolivia (2005). (Note the high density of urban occupation and the dubious structural quality of housing.)

risk scenarios, fundamental for land-use planning; (3) because hazards can only rarely be reduced, policy instruments focus on the reduction of vulnerability, according to the degrees of potential damage; (4) definition of who bears the risk and how, according to the capacity of public and private entities involved and related to their responsibilities; (5) design, building, operation, lease, transfer and reclamation contracts, guided by adequate regulatory frameworks and *ex ante* damage assessments following time–space distributions; (6) *ex ante* determination of priority areas of intervention, location of clean-up activities, temporary shelters, restoration of basic services, rehabilitation and reconstruction; (7) areas for further investments to reduce future disasters.

Fig. 15. Stabilization structure in Jarañapampa, western slope of La Paz, Bolivia (2004). (Note the high density of urban occupation below.)

A change of paradigm is needed to depart from traditional and obsolete models focused on the 'pre–during–post' cycle of disasters, towards an *ex ante* analysis emphasizing the knowledge of their causes and effects and their integration into the phases of planning for development. Risk management must be performed at all times and in all places, even if there is no disaster looming.

The effect of disaster on small economies

It has been observed that disasters induce temporary increases in the fixed capital formation (FCF) (such as buildings and structures, land improvements, new mineral resources), mainly in the short term and specifically in the building sector. However, this rise is usually detrimental to the formation of human capital and generates highly negative environmental impacts besides being unsustainable, as resources are diverted to reconstruction from originally planned social investments, fiscal earnings are reduced and internal revenues are delayed or do not occur at all, current expenses increase to deal with response and reconstruction actions, and indebtedness increases and payment capacity decreases, as the balance of payment loses equilibrium because imports for reconstruction are boosted.

The FCF, one of the most important foundations of development, evolves as is schematically represented in Figure 17 (modified after Cochrane 1997). Immediately after a disaster a sudden reduction occurs, caused by direct and indirect losses. This is followed by an accelerated increase as a consequence of the arrival of fresh resources (loans, donations, remittances) activating reconstruction. After a period (usually 1 year or a maximum of 2 years) this hyperactivity decreases, followed by the return to traditional social–economic dynamics. The exhaustion of donations and loans

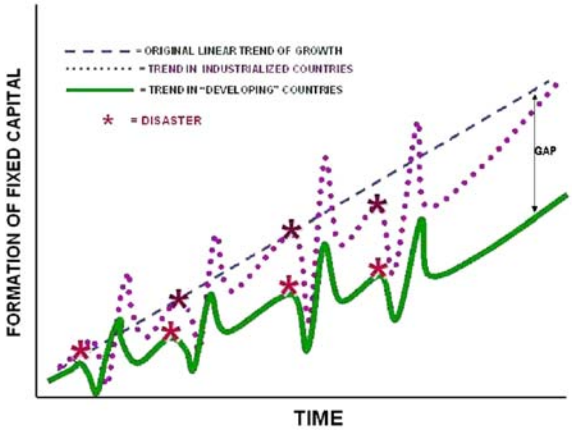

Fig. 17. Effect of disasters on the fixed capital formation in small national economies. Comparison between 'industrialized' and 'developing' countries (modified after Cochrane 1997).

and the beginning of payment of debts and services are accompanied by a loss of priority for reconstruction. Even if the FCF trends towards stabilization and return to the original growth rhythm, it is frequently altered from its original trend, which it is difficult to gain. There is a noteworthy difference in countries with larger and industrialized economies, where the impact of disasters is swiftly mitigated and recovery is easier. Besides, disasters rarely occur in isolation. It is more frequent to have sequences of disasters affecting a country and the accumulation of impacts. After each disaster, the distance from the original trend becomes wider. Figure 18 shows an example from Costa Rica, where a succession of disasters has increasingly damaged the economy.

The same reasoning can be applied to other macroeconomic indicators, such as the gross domestic product (GDP). According to the Economic Commission for Latin America and the Caribbean (CEPAL; 2001*a*, *b*) and Charvériat (2000), the influence of disasters is clear. Figure 19 shows the impact of 27 major disasters on the GDP of 14 countries (preceding year, the year of the disaster and the following years). The trend is clear, even if the average of all cases is considered, as shown in Figure 20.

Financial protection

The determination of risk tolerance in a country must first incorporate the knowledge of financial exposure and its resilience. A balance must be found between preventive–mitigation investments (risk retention) and the coverage of eventual losses (risk transfer) (see Table 2). Financial strategies should be based upon scenarios taking into account rational thresholds of 'accepted' versus 'acceptable' risk levels, and benefit/cost ratios as decision-making tools. These scenarios should also consider the share of the cost of damage borne by the population, private productive sectors and the government's fiscal reserve capacities. Their resilience is thus established. National and local governments can choose among various financial instruments to protect the investments by retaining or transferring risk. In industrialized countries the most frequent tool is the insurance market, followed by weather-indexed hedge funds (applicable to agriculture), micro-credits, *ex ante*

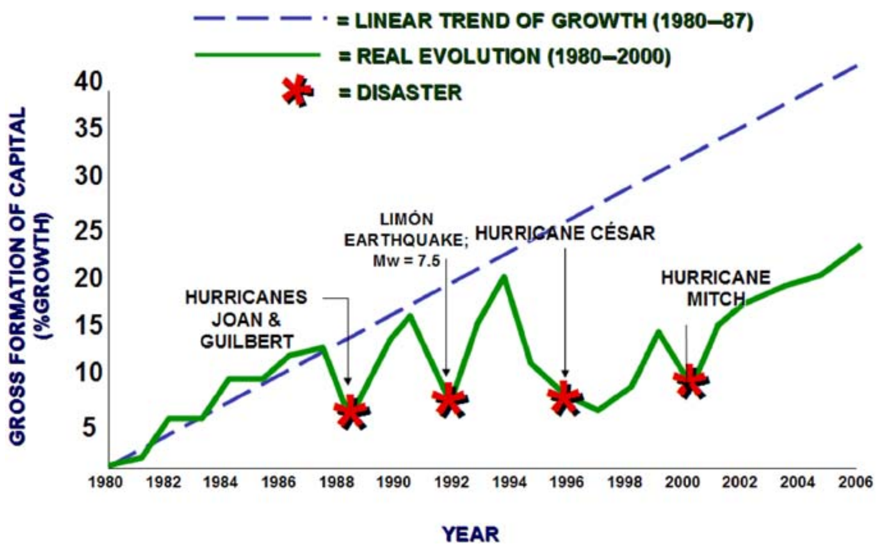

Fig. 18. Variation of the fixed capital formation caused by the impact of disasters in Costa Rica (1980–2000; after Anonymous 1995, 1996, 1997, 1998; Mora 1995, 2001).

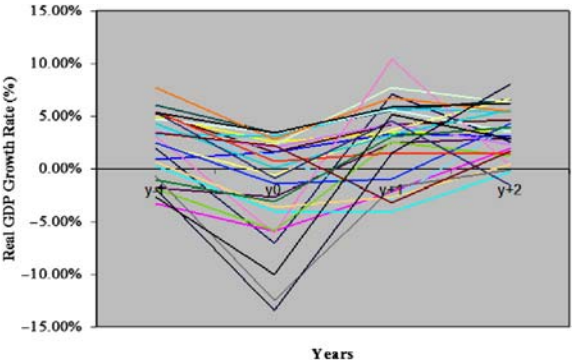

Fig. 19. Variation of the gross domestic product after 27 major disasters in 14 countries, comparing the previous year, the year of the disaster and the following years (after Charvériat 2000).

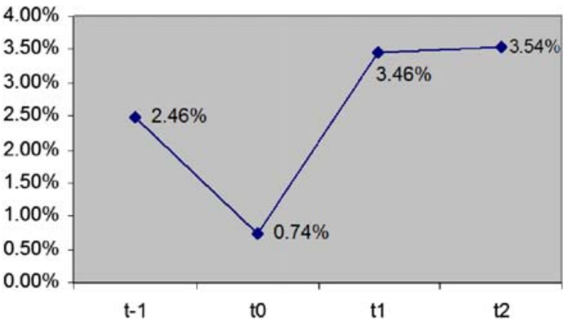

Fig. 20. Variation of the average gross domestic product caused by 27 major disasters in 14 countries from Figure 19 (after Charvériat 2000).

contingency credits (anticipated payment of quota, comparatively reduced and aimed to having *a posteriori* access to lower cost pre-agreed financial resources) and emergency funds (most frequently used in developing countries).

Considering its cost, the insurance market is an efficient option to reduce fiscal deficit during reconstruction after a major disaster, particularly in countries where governments own a large share of public facilities and utilities. However, it should be pointed out that insurance, although it can be financially efficient in protecting losses, can also create a false security by admitting the possibility of the loss and by reducing the incentives for investment in adequate design, prevention and mitigation measures. Furthermore, insurance markets require appropriate regulations and indexations, which is rather difficult to find at present in many developing countries. Weak legal and regulatory frameworks, technical and non-technical barriers, and lack of knowledge about hazards and vulnerability influence financial models and the high cost of insurance. The best approach would be to first establish a balance between retention and transfer tools. Table 3 briefly compares pros and cons of these instruments.

Financing post-disasters

It has been observed that once a major disaster occurs, most governments act as *de facto* and *ex post* financial agents, as non-existent adequate financial protection requires that they absorb fiscal obligations and financial liabilities, usually over their own capacities. This burden could be classified into three distinct categories: (1) expenses to cover the financial costs of damage to infrastructure and services, (2) expenses originating from political pressure to support an insufficiently insured private sector; (3) subsidies to provide goods and income to the poorest levels of society.

Bilateral and multilateral assistance becomes an important way to mitigate financial necessities through reimbursable and non-reimbursable funding, and, in some cases, the restructuring of debts. However, systematic access to available *ex post* financial resources (e.g. donations, subsidized or concessional loans with low interest rates) could create perverse incentives by promoting dependence. In any case, non-reimbursable assistance is far from being significant in relation to the magnitude of the needs to be overcome. According to Freeman *et al.* (2003), international financial assistance received in relation to losses since 1960, estimated as a share of GNP (Fig. 21), has covered only around 8.6% of the costs caused by disasters (the correlation coefficient of this regression is 0.55 after filtering atypical values (Freeman *et al.* 2003)) in 16 Latin American countries. It is evident that there is no room for optimistic expectations that donations will be sufficient to solve the financial problem of disasters. An unclear financial protection scheme in a country could lead to the redirection of fiscal resources to cover rehabilitation and reconstruction. This

Table 2. *Risk management for development projects*

Not to generate new vulnerabilities
Whatever is already built and vulnerable should be improved according to a rational definition of 'acceptable risk'
In case of not being able to reduce the vulnerability, risk must be financially transferred to anticipate the coverage of eventual losses
Decisions should not only be made considering financial arguments but should be integrated to social perspectives
The nation must always have enough resources to cope with the needs of all phases of risk management
Keep in mind that the '*post*' of a disaster is inevitably the '*pre*' of the next

Table 3. *Pros and cons of different financial risk retention/transfer financial tools (modified from Freeman* et al. *2003)*

	Reserve funds	*Insurance*	*Contingent credits*
Pre-disaster costs	Deposits through time before the disaster difficult to estimate	Premiums paid during years previous to disasters	High cost of maintenance during years previous to disasters
Post-disaster benefits	Only reserve funds and interest obtained and available	All funds made available by contracts, minus deductibles	All funds defined as necessary, made available
Post-disaster costs	None	None	Large service of debt and smaller capacity to contract future additional debts
Incentives for prevention	Only if risk is well known	Not necessarily	Not necessarily

practice becomes inadequate and dangerous to the sustainability of development, by expanding the impact of disasters through space and time to segments, regions, populations and sectors perhaps not originally affected by the disaster.

Spatial modelling and risk management

Spatial modelling is an important tool in risk management. It can help improve the quality of projects by detecting hazards and reducing vulnerability to 'acceptable' levels of risk. It also contributes in defining ways to guide the re-establishment of basic services after a disaster (e.g. water, electricity, health, telecommunications, transportation, education). It provides inputs for cost-effective, quick and safe reconstruction, and to avoid the creation of further vulnerability. Spatial modelling could become particularly useful as an orienting assistance tool for decision-making, land-use policies and action plans. It enhances capacities and degrees of awareness when focused on specific cultural, social, geographical and sectoral delimitations and jurisdictions. It allows visualization of geodynamic variables, threatened areas and assets, and additional investments required to reduce the degrees of risk (Mora & Keipi 2006).

Thematic maps and spatial models are useless if they are not designed to be understood by ordinary people and local and national authorities with little or no background in engineering or science. Unfortunately, this problem has been commonplace for so-called 'risk maps', which, besides being incomprehensible to most decision-makers, are only 'snapshots' of particular scenarios, most of the time depicting hazards only at a particular space, time and location of exposed elements. These cannot be denominated as 'risk scenarios'.

Risk scenarios and their cartographic representation should be designed to show frequency, recurrence, intensity and spatial distribution of hazards and vulnerability. These will define levels of risk, help raise awareness, and incorporate population, private sector and governments into the decision-making process. Spatial models allow initiation of evaluations of costs and cash flows involved in structural and non-structural measures to be undertaken in risk management (Mora & Keipi 2006).

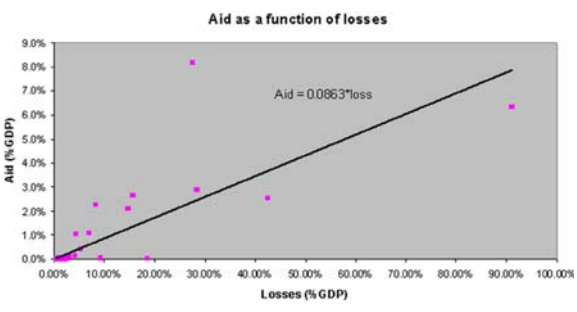

Fig. 21. International non-reimbursable assistance v. losses caused by disasters (after Freeman *et al.* 2003).

Conclusions

Natural hazards combined with social, economic and environmental vulnerability have resulted in disasters of devastating consequences in Latin American and Caribbean countries. Fatalities, social–economic losses and damage to infrastructure and services have been too high, have deepened social problems, and have hindered opportunities for proper development processes. Unfortunately, the predominant paradigm has been to respond to emergencies and disasters and not to reduce vulnerability. Incorporation of proactive risk management within development investments has not been a common practice. Present policies emphasize mainly preparedness and response activities, as they have higher public visibility. Prevention and mitigation, on the contrary, face significant financial and institutional limitations. Post-disaster support, including that from external sources, has become also a disincentive for investing in risk reduction. These are the reasons why disasters should not be considered to be simply 'natural'.

This paper has sought to explain the reasons for the lack of proactive disaster risk management and proposes a course of action to reduce the impact of natural hazards through preventive investment, planning, financial protection and spatial risk modelling. This process begins by ensuring that projects are conceived through an analysis of variables controlling the causes and consequences of risk. Any project should be designed to be resistant to hazards. Prevention and mitigation measures conforming to risk management, together with financial protection, should be agreed among public and private stakeholders.

Engineering geologists could have a direct role in applying criteria and establishing 'hazard impact assessments' (HIA), as is now usually done for environmental impact assessments (EIA). It is important to keep in mind that it is necessary to focus more specifically on the development process than on the disaster itself. This can be performed by risk space–time modelling, connected to adequate design, construction, land-use and financial protection principles, instead of creating more vulnerability. This is a perspective consistent with the ultimate goal of the profession.

Disasters have clear negative consequences, such as: human suffering; deterioration of quality of life and social well-being; unequal and selective effects on the most vulnerable groups (the poor, women, children, ethnic minority groups); losses of capital and investments, which accumulate and consequently become an impediment to development; investments and development projects being hindered by an almost continuous priority for reconstruction; higher current costs to replace the patrimony already covered and depreciated.

On the other hand, opportunities also arise that may be appreciated as positive lessons learned: exposure of the vulnerability caused by inadequate and unsustainable development models; opportunities for reconstruction without rebuilding vulnerability and with respect for land-use principles; involvement of the public and private sectors, and civil society, in the effort; defining adequate criteria and levels for 'acceptable' instead of only 'accepted' risk.

Acknowledgements. The author wishes to thank R. Barrios, M. Harbitz, J. Ferriter and D. Canfield for their reviews and assistance during the preparation of this paper. The opinions expressed are those of the author and do not reflect the official position of the author's former employer, the Inter-American Development Bank.

References

Anonymous 1995, 1996, 1997, 1998. *Estado de la Nación. Proyecto Estado de la Nación en Desarrollo Humano Sostenible*. United Nations Development Programme. Imprenta Segura, San José, Costa Rica.

BID 2000. *El desafío de los desastres naturales en América Latina y el Caribe: Plan de acción del Banco Interamericano de Desarrollo*. Departmento of Sustainable Development, Inter-American Development Bank (BID), Washington, DC.

Cardona, O. 2006. *Indicators of disaster risk and risk management in Latin America and the Caribbean*. Instituto de Estudios Ambientales (IDEA), Department of Sustainable Development, Inter-American Development Bank, Washington, DC.

CEPAL 1996. *Efecto de los daños ocasionados por el huracán César sobre el desarrollo de Costa Rica*. Unpublished report. Comisión Económica para América Latina, Naciones Unidas, Santiago de Chile y Ciudad de México.

CEPAL 1998. *República Dominicana: Evaluación de los daños causados por el huracán Georges, 1998*. Unpublished report. Comisión Económica para América Latina, Naciones Unidas, Santiago de Chile y Ciudad de México.

CEPAL 2000. *Efectos socioeconómicos de las inundaciones y deslizamientos en Venezuela, 1999*. Unpublished report. Comisión Económica para América Latina y el Caribe; Misión CEPAL-PNUD con aporte del Banco Mundial, CAF, OPS y PNUMA, Santiago de Chile y Ciudad de México.

CEPAL 2001*a*. *El terremoto del 13 de enero de 2001 en El Salvador. Impacto socioeconómico y ambiental*. Comisión Económica para América Latina y el Caribe, Naciones Unidas y Ciudad de México.

CEPAL. 2001*b*. *El Salvador: evaluación del terremoto del 13 de febrero de 2001*. Comisión Económica para América Latina y el Caribe, Naciones Unidas y Ciudad de México.

Charvériat, C. 2000. *Natural Disasters in Latin America and the Caribbean: an overview of risk*. Inter-American Development Bank, Research Department, Working Paper, **434**.

Cochrane, H. 1997. *The macroeconomic effect of disasters in developing countries*. 1st Hemispheric Congress for Natural Disasters Reduction and Sustainable Development, Miami, Florida, October 1996. University of Florida unpublished report.

Freeman, P., Martin, L., Linneroot-Bayer, J., Melcher, R., Pflug, G. & Warner, K. 2003. *Disaster risk management—national systems for comprehensive management of disaster risk—financial strategies for disaster reconstruction*. Inter-American Development Bank, Washington, DC.

Mora, S. 1995. The impact of natural hazards on socioeconomic development in Costa Rica. *Environmental and Engineering Geoscience*, **3**, 291–298.

Mora, S. 2001. América Latina y el Caribe; las amenazas naturales y los desastres: desafíos para el desarrollo sostenible. *In*: *Memorias III Congreso Suramericano de deslizamientos*. Sociedad Colombiana de Mecánica Suelos, Comité Colombiano de Ingeniería Geológica, Cartagena de Indias, Colombia, 96–110.

Mora, S. 2003. *La gestión del riesgo en la República Dominicana: relación y aportes del Banco Interamericano de Desarrollo*. Unpublished report. COF/CDR-OVE-REI/EN1.

Mora, S. & Barrios, R. 2000. Estrategias, políticas y prácticas para reducir el riesgo ante los peligros naturales y la vulnerabilidad. *In*: *Memorias XVI Seminario Venezolano de Geotecnia: 'Calamidades geotécnicas urbanas con visión al siglo XXI, la experiencia para proyectos del futuro'*. Caracas, 14–26.

Mora, S. & Keipi, K. 2006. Disaster risk management in development projects: models and checklists. *Bulletin of Engineering Geology and the Environment*, **65**, 155–165.

Mora, R. & Lücke, O. 1998. *Influencia de la geodinámica externa sobre los daños causados por el huracán Georges en República Dominicana (Setiembre, 1998)*. Unpublished report. Inter-American Development Bank, Washington, DC.