SCIENCE FOR A BETTER LIFE:
DEVELOPING REGIONAL SCIENTIFIC PROGRAMS IN PRIORITY AREAS
FOR LATIN AMERICA AND THE CARIBBEAN

VOLUME 2

UNDERSTANDING AND MANAGING RISK ASSOCIATED WITH NATURAL HAZARDS: A COMPREHENSIVE SCIENTIFIC APPROACH FOR LATIN AMERICA AND THE CARIBBEAN

OMAR DARÍO CARDONA • JUAN CARLOS BERTONI • TONY GIBBS • MICHEL HERMELIN • ALLAN LAVELL

ICSU
International Council for Science
Regional Office for
Latin America and the Caribbean

CONACYT
Consejo Nacional de Ciencia y Tecnología

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FOREWORD

Founded in 1931, the International Council for Science (ICSU) is a non-governmental organization that plans and coordinates interdisciplinary research to address major issues of relevance to both science and society. Over the years the geographical breadth of ICSU activities has changed. Increasingly a major emphasis for ICSU has been the development of scientific capacity in developing countries and the integration of these scientists in international research initiatives.

The creation of three ICSU Regional Offices, established in Africa, Asia and the Pacific, and Latin America and the Caribbean also marks a fundamental change in ICSU structure, the aim of which is two-fold. First, it should enhance the participation of scientists and regional organizations from developing countries in the programs and activities of the ICSU community. Secondly, it will allow ICSU to play a more active role in strengthening science within the context of regional priorities through scientific collaboration.

Especially in regard to Latin America and the Caribbean, this is an important step in bridging the 'islands of competence' that exist in every country and that together will be able to advance significantly the scientific research agenda in the region. The first step towards the establishment of a Regional Office was the appointment in 2006 of the Regional Committee for Latin America and the Caribbean, composed of renowned scientists of the region.

The Regional Office for Latin America and the Caribbean was the third to be established and was inaugurated in April 2007. It is hosted by the Brazilian Academy of Sciences, in Rio de Janeiro, Brazil, and supported by the Brazilian Ministry of Science and Technology, ICSU, and CONACYT Mexico. From October 2010 it will be hosted by the Mexican Academy of Science, with the support of CONACYT Mexico.

Based on the ICSU Strategic Plan 2006-2011, the Regional Committee has selected four priority areas to be developed:

- Mathematics Education;
- Biodiversity: knowledge, preservation and utilization of biodiversity of all countries of the Latin American and Caribbean region, and to ensure that the scientific community of the smaller countries of the region are fully integrated in DIVERSITAS;
- Natural Hazards and Disasters: prevention and mitigation of risks especially of hydrometeorologic origin with special attention to the necessary social science research;
- Sustainable Energy: assessment of the existing capacities in the LAC region and the social impact of the use and development of new energy resources.

Four Scientific Planning Groups were appointed to develop proposals that reviewed the current status of the priority area in the region and to formulate a set of detailed objectives and targeted areas of research to be developed in the next few years.

Engaging highly qualified scientists from Latin America and the Caribbean, the Scientific Planning Groups did outstanding work within a restricted time limit. We thank each and every one of the participants for their enthusiasm and dedication.

This document is the final report of the Scientific Planning Group in Natural Hazards and Disasters, which is being submitted to the scientific community in the expectation of effectively influencing the development of scientific research in this area in the years to come.

Alice Abreu
Director
Regional Office
for Latin America and the Caribbean

José Antonio de la Peña
Chair
Regional Committee
for Latin America and the Caribbean

EXECUTIVE SUMMARY

Disasters associated with environmental hazards reflect and signify unmanaged risks, and may also be seen as representing unresolved development problems. Disaster risk is defined as the probability of future damage and loss associated with the occurrence of environmental hazards, where the levels and types of loss are determined by the levels of exposure and vulnerability of each society. Disaster is a social condition in which the normal functioning of society has been severely interrupted by the amount of loss, damage and impact suffered.

Disaster risk and disasters originate from socio-environmental processes. The notion of "social construction" of risk is now widely used to capture the idea that society, during its interaction with the physical world, "constructs" or generates disaster risk by transforming physical events into hazards through social processes that increase the exposure and vulnerability of people, their livelihoods, production, and support infrastructure and services. Disaster risk and disasters have been escalating constantly over the last five decades, and due to our current climate-change processes, they can be expected to increase even further in the future if concerted actions for risk reduction are not enacted. Such disaster risk reduction requires the implementation of disaster risk management principles and practices, which reduce the existing risks (corrective management), and control the development of new risks in the future (prospective management).

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THE RESEARCH CONTEXT

Understanding risks, the processes that lead to their construction or development, and the creation of adequate risk reduction and control mechanisms, requires improved and increased research efforts. Given the multi-dimensional nature of risk, and the multiple natural and social factors that intervene in their development and determine the ways in which society understands them and reacts towards them, such research must be based at least on multidisciplinary protocols, but ideally on protocols that promote interdisciplinary and transdisciplinary research. Although discipline-oriented research has much to offer in understanding particular facets of the problem, the only way to achieve a real understanding of risk and disasters, the ways in which society understands them and reacts to them, and our opportunities for risk reduction, is the use of more complex protocols that require greater levels of conceptual development, agreement and homogeneity, as well as the promotion of methodological frameworks that encourage and allow an interaction between natural, applied and social sciences, while promoting a wider stakeholder participation.

To this date, although progress has been made in bringing social and natural sciences together for the study of risk and disasters, on the whole this hasn't gone further than broad-based multidisciplinary efforts. Research efforts are still more likely to be of the disciplinary kind, and while basic, natural and applied sciences continue to provide valuable information for understanding and decision making, social sciences tended to stagnate, after two decades of development on this topic, due to a lack of research momentum, and support on an organized, collective basis. The present ICSU program will attempt to advance the promotion of multi- and interdisciplinary research on risk and disasters, while providing new insights into risk management, decision making, implementation, and action.

PROGRAM GOALS

The particular objectives of this program will be to:

a. Promote interdisciplinary research on risk and disaster problems that includes: a more thorough knowledge of significant hazard events and patterns; a better understanding of risk construction processes; the promotion of risk measurement, evaluation, and analysis; the understanding and promotion of more adequate and comprehensive decision making processes; and the introduction of more permanent and consequent risk management schemes and principles.
b. Promote a kind of research that brings together studies, discussions and practices on climate change adaptation and disaster risk reduction.
c. Develop and promote methodologies for the integration of social and natural sciences into interdisciplinary research protocols. As well as methodologies that promote the transition between research and action, using participatory methods and considering the roles of all stakeholders.

d. Promote better interactions and understanding between the scientific and governmental policymaking communities, by developing better methods to transmit and relay information and knowledge to the latter.
e. Promote better interactions and understanding between the scientific community and its beneficiaries, the civil and private sectors in our society, by developing better methods to transmit and relay information and knowledge to the latter.
f. Support and promote research and capacity building efforts from a holistic perspective, stimulating the creation of relevant institutional frameworks to achieve it. This should strengthen our social, natural and applied sciences research capabilities, as well as our ability to interconnect on common conceptual and methodological grounds.
g. Promote the creation of a post impact multidisciplinary analysis board with research capability. Such board should be able to produce a quick post-mortem, or forensic-type analysis of disaster causes and impacts, which, should fuel public debates and lead to a review of existing practices failures. And then, based on this, to support and promote the creation of an independent reviewing committee on risk, disaster and research.

RESEARCH SUBJECTS AND METHODOLOGY

In order to promote these objectives, the program has identified four major research subjects that may be promoted through the development of individual or collective research projects and programs:

First, the identification of significant, as yet uncharted and unmapped natural hazard processes and patterns, which could be associated with current or future risk patterns and disasters.

Second, understanding the factors and processes (both social and physical) that contribute to the social construction of risks, and to the ways in which risk is socially, territorially and temporally distributed.

Third, identifying ways to evaluate, measure or gauge risk objectively (actuarially), and the ways in which risks are socially analyzed; i.e., the way risk is given real social meaning, and a basis is established for decision making in favor of, or against risk reduction and control.

Fourth, understanding decision making processes, and the real enactment or rejection of risk reduction and control measures, disaster preparedness, and response and recovery actions.

Although these four aspects or subjects, and their subdivisions are different, they can also be seen as concatenated, so their final output, in terms of risk management, will be influenced by the inputs garnered from each type of process and its contribution to the understanding and measurement of risk. When seen from the perspective of disaster risk and disasters *per se*, the more definitive or conclusive of these subjects relate, obviously, to the decision to act, reduce or control risk. Namely, the structure and configuration of research undertaken on the evaluation and assessment of causal factors should be directed optimally by an interest in the promotion of adequate decision making, and the identification of risk management needs and options. Of course, this doesn't mean that basic science, with its latent positive effects on understanding and decision making, shouldn't be encouraged. The three "knowledge" demands or contexts (new natural hazard identification and patterns, risk construction processes, and risk evaluation and assessment) are absolutely essential to achieve decision making, and must be seen as an integral part of it.

While recognizing the importance of maintaining an open-end approach to project proposition and development on the previous subjects, the ICSU's scientific planning group responsible for the development of this proposal identified six specific priority areas for further consideration and development: (1) the development of methodologies to support risk analysis in small and medium towns; (2) research on risk reduction in settlements located on sloping urban areas in the LAC region; (3) the development of risk-modeling and data platforms for countries in the region; (4) the development of risk and risk-management indicator schemes and practices; (5) research on real decision making processes at the national, regional and local levels; and, (6) research that provides a better foundation for promoting climate change adaptation, based on the experience garnered in the risk management field.

During the development of the four identified subjects and the creation of specific projects, attention must be given to the development of research protocols and methodologies that encourage interdisciplinary work, adequate processes of social communication that allow the incorporation of natural and applied science findings to risk-reduction activities, and encouragement of wide-scale stakeholder participation.

PROGRAM ORGANIZATION AND PROMOTION

The program would attempt to promote and finance research efforts under any of those subjects. This would be done through the establishment of a formally enacted research program linked to an established research and training facility, endowed with financial support from different supporting agencies. At the same time, any individual and collective research projects that wish to be seen as part of the ICSU-promoted collective effort could be "registered" under the program, as far as they are aligned with the objectives, conditions and methodological requirements set out in the present document.

SUPPORT ACTIVITIES

In addition to the research program, the scientific planning group recommended two types of support activities that are necessary to advance the program's objectives.

Research training and support

Multi-, inter- and transdisciplinary research should be the goal of all support garnered by the present program. In this sense, the program, and its financing mechanisms, should be instrumental for the establishment and promotion of educational and training modalities and mechanisms, which promote holistic, comprehensive, inter- and transdisciplinary approaches for research and problem formulation.

This may be achieved in a number of ways.

First, research projects supported by this program should be required to incorporate on-site mechanisms that support and strengthen capabilities for interdisciplinary collaboration and work, and which could have a secondary effect in teaching programs led by project researchers. Incorporating young researchers in projects, and exposing them to interdisciplinary protocols, would be another secondary effect.

A second, more formal and institutionalized approach, would be the promotion and support given to the establishment of one or more interdisciplinary research and teaching facilities in the LAC region, linked to the existing national or regional institutions. An ideal mechanism could be the promotion of holistic educational opportunities through the involvement of students in research projects that are complementary to any formal educational opportunities offered.

A third complementary mechanism would be giving support and incentives to graduate courses on holistic and comprehensive risk-management principles, taught in established institutions.

Post-mortem or forensic studies of disasters in the region

The most valuable laboratory for studying risk and disasters is found in the impacts of real events. To learn effectively from these events, research teams, protocols and logistics must be developed well in advance, and all necessary institutional arrangements must be negotiated and in place. Although post event diagnostic surveys are carried out in the region, they are done in an uncoordinated way, and the lessons learned from them are insufficiently shared, and only rarely reviewed by peers.

There is need to establish a mechanism for post event diagnostic surveys that allows to understand the fundamental physical and social processes that led to risk and disaster; key issues from structural performance during earthquakes and hurricanes which have implications for public health and social and economic impacts; social responses to disaster, and; processes leading to recovery plans and procedures. Post event diagnostic surveys should be multidisciplinary, and support analysis for the improvement of mitigation planning, regulation and investment. Results of the diagnostic surveys should be shared with the professional and educational communities, and with other fields by means of the most appropriate and efficient information technology.

Such a facility, and the information it provides, would be the basis for establishing a permanent evaluating committee on risks and disasters in the region, whose work and results could serve as a pressing factor to initiate changes in practices and policies within the region.

1. INTRODUCTION: ESTABLISHING THE RESEARCH SUBJECT, AND ITS CONCEPTUAL AND METHODOLOGICAL APPROACH

1.1. DISASTER RISK AND DISASTER RISK MANAGEMENT

Risk, as seen in the context of disasters, may be defined as the potential damage and loss associated with the occurrence of physical phenomena (single, multiple or concatenated) of diverse types, intensities and magnitudes, which affect exposed and vulnerable human populations, their livelihoods, and their support mechanisms and infrastructure. Under certain circumstances, these damage and loss may reach such levels and consequences, that they must be considered large-scale "disasters" or "catastrophes." Sometimes, when faced with lower levels of loss and damage, now it's common to talk about small- and medium-scale disasters.

As such, risk is the result of the interaction, in time and space, between potential physical events and the exposed and vulnerable elements of social and environmental systems. In such interaction, those physical events are transformed into hazards with real potential to contribute to future loss and damage. This latency of risk is what allows reducing and preventing it by means of diverse disaster risk management principles, strategies and instruments. And these may be developed in the context of existing risks (corrective management) or the avoidance of future

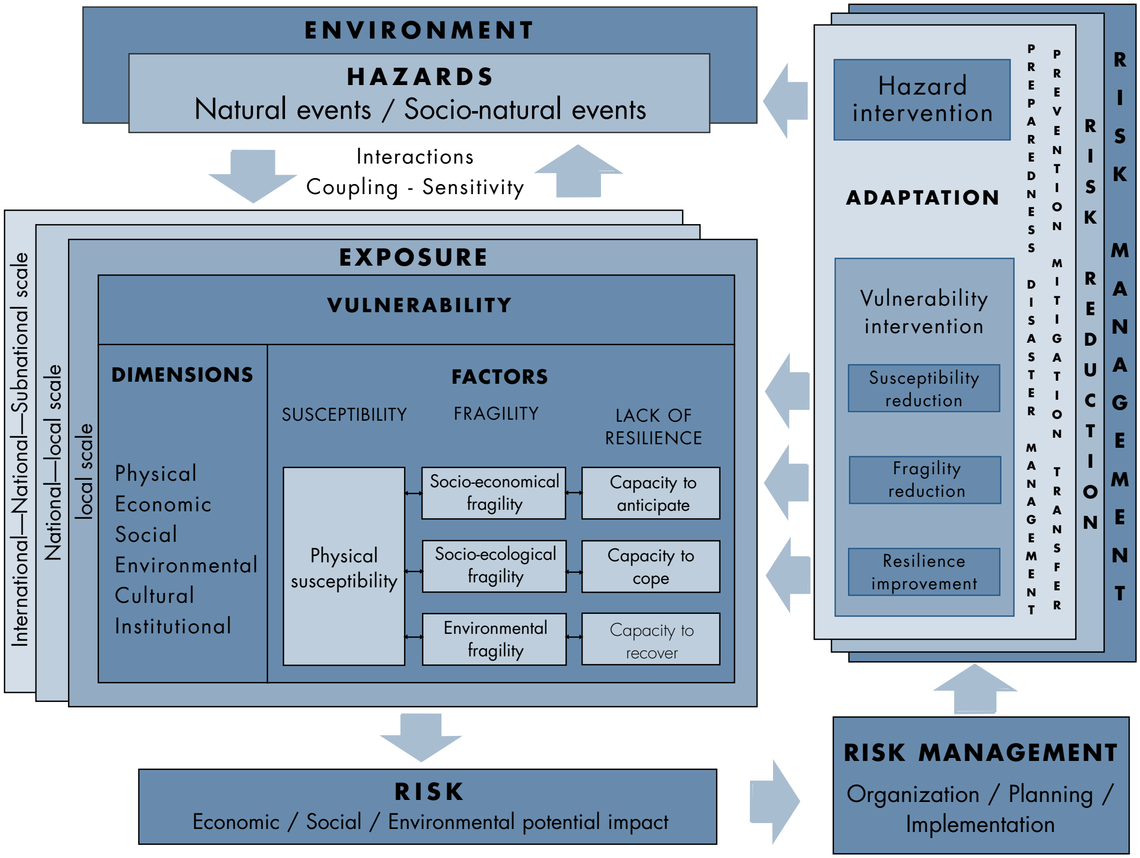

Figure 1. Theoretical framework and model for an holistic approach to disaster risk assessment and management. Adapted from Cardona (1999: 65), Cardona and Barbat (2000), IDEA (2005a, b), and Carreño, Cardona, and Barbat (2007).

risks (prospective management). Disaster risk management may be defined as a social process that seeks to reduce, predict and control disaster risk factors in a development framework, by designing and implementing appropriate policies, strategies, instruments and mechanisms. (Figure 1 provides a summary of the causal and interventional aspects associated with such view of risk).

Disaster may be seen as the actualization or materialization of existing disaster risks. That is to say, that latent risk conditions are transformed into real damage and loss when a triggering physical event occurs. The existence of risk is a *sine qua non* prerequisite for future disasters. Disaster is the product of complex interactions between the physical world, the natural and artificial environments, and the behavior, functioning, organization and development of human societies. As such, it's both a product and a consummated reality, but at the same time, the existence of disaster conditions leads to new social processes, and new or transformed risk conditions. Risk is a continuum, while disaster is one of its many "moments" or "manifestations."

The main goal of the present ICSU-sponsored research program is *to contribute to a better and more effective understanding of disaster risk, and disaster risk management, in the Latin American and Caribbean region, while promoting research within a comprehensive interdisciplinary framework*.

While mainly concerned with disaster risk reduction (mitigation) and prevention, including its recovery aspects, such research will also contribute to a greater understanding and better interventions in the disaster preparedness and response part of the risk management formula. On the other hand, while mostly concerned with natural hazards and their impacts, this must be accompanied by a concern for what now is known as socio-natural hazard. In other words, physical phenomena and their associated hazards, which are the product of human interventions in the natural environment, and which range in scale and importance, from the impacts of global climatic change (related to land use change and carbon emissions), to small-scale floods or landslides related to local processes of deforestation and slope destabilization. Technological hazards will only be considered to the extent they are concatenated with natural and socio-natural hazards to increase its impacts and effects. Biological hazards will also be considered, but only when they are a byproduct of given disaster conditions.

1.2. A COMPREHENSIVE SCIENTIFIC APPROACH

Since disaster risk is not an autonomous or externally generated circumstance (as seen in natural phenomena or events *per se*) to which society has to react, adapt or respond, but rather the result of interactions between society and its natural and/or artificial environment, it's only through the knowledge of such interactions, and the factors that determine them, that an adequate understanding of risk may be achieved. And with such understanding, the options for social intervention and control of disaster risk (and risk in general) become likely and feasible.

The complex interactions between human society and its environment, which explain the existence of disaster risks, signify also that our options for understanding risk and successful intervention require the harmonious and comprehensive presence, and application, of relevant social, natural, basic, and applied science knowledge and methods. Risk is the result of interactions between the inert, dynamic physical world, and the living, social world, and therefore, the only possibility to understand it comes about when an insight of the different contexts and interactions is achieved.

Syncretism, a means by which social science factors or conditions are introduced on top of —or in parallel to— physical factors and knowledge, will not lead to the needed understanding of risk. Knowledge of each of the factors that contribute to risk (physical events transformed into hazards, vulnerability and exposure) may be undertaken independently by the physical and social sciences (using multidisciplinary protocols). However, understanding such dialectical interactions and the final product to which society responds, or doesn't respond, and the profiling of relevant and feasible interventions, requires also more integrative inter- or transdisciplinary models.

Given the still inadequate situation of comprehensive research, the ICSU has a significant role in focusing analysis and discussion, promoting integrative approaches, and developing ideas for interdisciplinary methods to achieve a greater knowledge, and more pertinent guidelines for decision making in the risk mitigation and prevention areas. A basic starting point for this is accepting that, although the physical world and the processes it encloses and displays, as well as the potential hazards it convenes, are *sine qua non* requirements for talking about, and understanding disaster risk, in the final equation, risk is socio-ecological. And the basis for intervention may be laid down, and developed, by the ways in which society tends to measure, understand, perceive, relate to, and assign importance to risk (and risk factors). Reversing the historical and current trends toward increased disaster losses will require such integration, as well as the results that this may bring about in terms of increased relevance and application of scientific knowledge. The explanation of the observed non-linear or causal interactions between our ever-increasing knowledge on multiple aspects and factors of risk and disasters, and the ever-increasing disaster losses, is found, among other things, in the lack of integration and communication.

Assigning importance to, and taking deliberate decisions based on information and knowledge related to the reduction or control of risk, is an essential factor in establishing an area of concern, study and intervention where risk constitutes a socially and politically constructed problem that demands a solution, and where risk assumes levels of relevance that demand intervention and control.

2. RATIONALE FOR THE RESEARCH PROGRAM

2.1. THE DISASTER RISK AND DISASTERS ISSUE

The launch of the UN International Decade for Natural Disaster Reduction (IDNDR) in 1990, and the International Strategy for Disaster Reduction (ISDR) in 2000, which were accompanied by successive statements derived from the World Disaster Conferences held in Yokohama and Hyogo in 1994 and 2005, respectively, are clear signs of the increased global interest and concern for disaster risk and disaster-related issues. The Inter-American Disaster Conferences held in Cartagena (1994) and Manizales (2004), within the Latin America and Caribbean region, are parallel events that echo such concerns at the regional level.

Some relatively recent events (such as the El Niño in 1997-1998; the hurricanes George and Mitch in 1998, Jeanne and Ivan in 2004, and Wilma in 2005; the tropical storm Stan in 2005; the Vargas' flow of debris in 1999; the earthquakes in El Salvador in 2001, in Colombia's coffee-growing area in 1999, and in Peru's Pisco region in 2007; the serious floods in Bolivia in 2006 and 2007, and in Tabasco, Mexico, in 2007; and the eruptions of Ecuador's Tungurahua Volcano in 2006, and Chile's Chaitén Volcano in 2008) are but the most dramatic cases of serious and permanent problems that affect millions of persons every year in the region. And behind those events, and the disasters they help to conform, there's a permanent and changing process of risk construction associated with non-operational development models, increased exposure in coastal, riverside, lake, volcanic and seismic areas, and ever-increasing vulnerability levels associated, among other things, with increased poverty and, nowadays, also with increased food security problems.

The human, economic, material, cultural, psychological, and historical losses and damages associated with successive events increased steadily over the last four decades, but mainly those associated with hydrometeorological events. Such losses increased dramatically over the last ten years. One possible explanation for this is the increased effect of global climate change. Whether this is or not the explanation for the trends seen over the last 15 years, we certainly can expect greatly increased impacts over the next years in relation to changes in rainfall, storms, and other related hydrometeorological phenomena. When combined with likely increases in exposure and vulnerability, the panorama is quite serious, and the need for evidence-based, research-supported interventions becomes even more critical. There is a growing body of evidence and lines of reasoning which suggest that our experience with mitigation and prevention of ongoing, everyday, and historical disaster risk is one of the most efficient and effective ways to establish options and incentives to reduce the risks associated with climate change (something that climate change specialists call *adaptation*). Therefore, we need —and demand— a better coordination and integration of disaster risk and climate change management issues. Research can help substantiate such view, and contribute to close the gap between the practitioners and institutions dedicated to each of these complementary, but different areas of enquiry and practice.

2.2. INTERACTIONS BETWEEN NATURAL AND SOCIAL SCIENCES IN RISK RESEARCH: THE CHALLENGE POSED BY COMPREHENSIVE INTERDISCIPLINARY RESEARCH

Despite the many calls for interdisciplinary and transdisciplinary methods and studies over the last two or three decades, the subject of disaster risk is still dominated by partial approaches in which different sciences and disciplines contribute their specialized knowledge to the understanding of diverse facets of the problem. Though such approaches are certainly relevant for risk and disaster studies and interventions, they neither define nor limit the topic on their own. That's why some authors suggest that we don't have, as yet, a comprehensive conceptual framework or theory that is widely adopted or understood by all specialized sciences or disciplines related to the study of disaster risk and disasters. Thus, a geoscientist who studies and contributes to the understanding of seismic activities, patterns and processes, can't be considered as a disaster risk or disaster specialist *per se*, but rather as an expert in seismic activity, which is a legitimate area of endeavor with or without direct interest in disasters. Similarly, an engineer or sociologist could study buildings or social behaviors that are relevant to risks and disasters, but that doesn't make them experts, *per se*, in disaster risk or disasters.

The transition between discipline specialization on any aspect related to the understanding of such risk, and becoming a disaster risk (problem area) specialist, requires other ingredients, among which having a common analytical and conceptual framework for approaching and understanding risk is but one. The challenge faced by disaster risk studies is building a pivotal notion or concept, and articulating our research processes and actors in an integrative fashion around such center, considering always that such research and its results should optimally be based on a demand and need for policy- and action-related information and analysis. The present research initiative will promote a comprehensive research method and will, hopefully, contribute to advances in interdisciplinary methods and results.

From the scientific and inter-scientific perspective, the discipline-oriented history of research on risk and disasters in Latin America and the Caribbean (LAC) may be typified, or caricatured, in the following and brief way (see Section 4, for a more detailed analysis).

The early dominance of natural and applied sciences research on physical and hazardous phenomena (seismic, volcanic, geodynamic, meteorological, and hydrological), and the way human-made structures respond to them, led to the growth, consolidation, and dominance of physical sciences in the field of risk research during the 1950s-1970s period. And despite the efforts to increase the notoriety, relevance, presence, and impact of the social sciences point of view, most research and teaching on the topic are still dominated by physical and applied sciences in the region. The increased demand from disaster agencies and international financing organizations for social science studies, as well for the measurement and consideration of social causes and impacts, has led to an increased integration of social science aspects into research studies stimulated and promoted by physical sciences. However, this is more likely to be an addition, instead of something fully integrated and methodologically sound from the interdisciplinary perspective. Multidisciplinary work is far more prevalent than the efforts at the inter- or transdisciplinary scientific levels.

In general, social sciences haven't managed to generate and establish specialized disaster risk research institutions at the university level in LAC —as has been achieved in the developed world. And it has been impossible to promote and sustain interdisciplinary research facilities. Risk and disaster research is more likely to be promoted on an individual or group basis, than on an institutional basis. Therefore, research promoted on a comprehensive scientific basis has been scarce.

One of the main added values of the current program is the way it promotes research subjects and protocols that demanded, from the outset, the confluence of social, natural and applied sciences for the definition of study objects and methods. Hopefully, one of the outcomes of such scheme will be the creation of one or more comprehensive LAC-based risk and disaster research institutions, such as the ones seen in developed countries, with a commensurate interest in the promotion of more comprehensive teaching programs.

3. SPECIFIC GOALS OF THE RESEARCH PROGRAM

a. Promote interdisciplinary research on risk and disaster problems that includes: a more thorough knowledge of significant hazard events and patterns; a better understanding of risk construction processes; the promotion of risk measurement, evaluation, and analysis; the understanding and promotion of more adequate and comprehensive decision making processes; and the introduction of more permanent and consequent risk management schemes and principles.
b. Promote a kind of research that brings together studies, discussions and practices on climate change adaptation and disaster risk reduction.
c. Develop and promote methodologies for the integration of social and natural sciences into interdisciplinary research protocols. As well as methodologies that promote the transition between research and action, using participatory methods and considering the roles of all stakeholders.
d. Promote better interactions and understanding between the scientific and governmental policymaking communities, by developing better methods to transmit and relay information and knowledge to the latter.
e. Promote better interactions and understanding between the scientific community and its beneficiaries, the civil and private sectors in our society, by

developing better methods to transmit and relay information and knowledge to the latter.

f. Support and promote research and capacity building efforts from a holistic perspective, stimulating the creation of relevant institutional frameworks to achieve it. This should strengthen our social, natural and applied sciences research capabilities, as well as our ability to interconnect on common conceptual and methodological grounds.

g. Promote the creation of a post impact multidisciplinary analysis and reviewing board with research capability. Such board should be able to produce a quick post-mortem, or forensic-type analysis of disaster causes and impacts, which, in turn, should fuel public debates and lead to a review of existing practices and their failures. And then, based on this, to support and promote the creation of an independent reviewing committee on risk, disaster and research in the region.

4. CURRENT STATE OF AFFAIRS REGARDING RISK AND DISASTER RESEARCH IN THE LAC AREA

4.1. NATURAL AND APPLIED SCIENCES: EMPHASIZING THE HAZARD AND TECHNICAL APPROACH

The term *"natural disaster"* has been used frequently in Latin America and the Caribbean (LAC) to refer to the occurrence of severe natural phenomena. Events such as earthquakes, tsunamis, volcanic eruptions, hurricanes, floods, and landslides, among others, have been considered synonyms of disaster. Unfortunately, this interpretation has favored the belief that nothing can be done when facing such disasters, other than improving the way to respond and rebuild. Such interpretation has led, as well, to consider disasters as events resulting from fate or bad luck, and even from supernatural and/or divine causes, when seen at the community level. Likewise, vestiges of such interpretation can be found in the legislation of most countries in the region, where the definition of "fortuitous acts" or "major causes" are still used along with statements such as "*The occurrence of a natural disaster, like an earthquake or volcanic eruption...*" In some cases, these kinds of events are called directly "Acts of God," as in certain legislation of Anglo-Saxon origin.

In LAC, as in other regions, geophysicists, seismologists, meteorologists, and geologists, among other scientists, have tended to promote or support the idea that disasters are a topic associated mainly, if not exclusively, with the physical phenomena that generate the natural events that contribute to disaster. In addition, despite technological advances in the prediction or prognosis of a future event, in most countries of LAC, budget decision makers justify quite often the lack of action and investment in seismological, geophysical, hydrological, and meteorological instrumentation arguing that damage and loss are unavoidable. A low level of investment in monitoring networks and research has been the common rule in most countries, notwithstanding the efforts of regional institutions such as the Regional Seismology Center for South America (CERESIS), the Pan-American Geography and History Institute (IPGH), and the Inter-American Institute for Global Change Research (IAI), among others, in commenting on, and promoting the need for better monitoring not just for prediction, but also for generating better scientific knowledge. Only recently, with the development of environment and science and technology ministries, and the establishment of new inter-institutional organizations (such as disaster prevention/civil protection structures, emergency commissions), some governmental scientific institutions related to hydrometeorology, geosciences and environment protection have been strengthened, and their instrumentation potential updated. Due to this, full-fledged and comprehensive early warning systems haven't been developed as they should; i.e., through the use of real time geospatial and information technology. For example, online ShakeMaps and rapid damage assessments have only been developed for two cities in the region.

During the second half of the Twentieth century, when technological advances contributed enormously to the knowledge of natural phenomena, in LAC it was commonplace to define risk as the calculation of the possible occurrence of a physical or social phenomenon. Such definition of risk is still commonplace among specialists who study phenomena such as earthquakes, landslides, and storms. In the 1970s, and even into the 1980s, the probability of an earthquake was usually considered to be synonymous with estimating seismic risk. In other words, many people still confused risk and hazard, and failed to distinguish between an intense natural event and a disaster. Risk cannot be understood exclusively as the possible occurrence of a natural phenomenon. This confusion has contributed to the misunderstanding of risk and disaster by the exposed people, and has sometimes been used by political authorities and other decision makers to avoid being blamed.

The declaration of the 1990s as the International Decade for Natural Disaster Reduction (IDNDR) by the UN General Assembly was, without a doubt, directly influenced by the natural sciences, and led in LAC to the beginning of a change in terminology. Toward the end of the 1980s, and particularly during the 1990s, the concepts of seismic hazards and threats started to be used more frequently to refer to what was previously named seismic risk. In fact, most seismic building codes in the region changed their terminology only during the last 15 years.

In LAC, as in other regions, the concept of risk in the applied and physical sciences commenced with the use of probabilistic models. From the probabilistic standpoint, one of the main worldwide contributions to hazard and risk prediction was made in LAC prior to other regions. Theory of probabilistic seismic hazard analysis was partially developed in Mexico, and the first published seismic zone map, which included levels of ground movement and its associated return periods by using attenuation relations, were made by engineering researchers from the Universidad Nacional Autónoma de México (UNAM) at the beginning of the 1960s.

Based on this approach, probabilistic hazard analysis was used, starting on 1970, to establish building code design constraints in Mexico. This was later introduced to California and elsewhere.

This seismic approach was adapted for other natural hazard evaluations, but the building codes in most countries were established only with seismic constraints, except in the Caribbean, where tropical storms are frequent and wind load standards (codes) for structural design were issued on the 1970s. On the whole, the implementation and updating of building codes in the region has been slow, due mainly to the lack of political will to adopt them as law. Starting on the 1980s, countries like Mexico, Chile, Peru, Venezuela, Colombia, and several Caribbean nations developed codes, policies or regulations for building construction, but their main problem has been their enforcement. Colombian engineers made outstanding contributions to the region and the world starting on 1980's. Such contributions were associated to the development of simplified earthquake-resistant construction guidelines for dwellings and middle-rise reinforced concrete buildings, as well as to vulnerability evaluation, and structural reinforcement of essential existing buildings, following technical guidelines developed in the United States. Now, these types of requirements have been included in most international standards and building codes worldwide.

Using the same exceedance rates approach proposed for hazard analysis, some probabilistic models were developed in Mexico and Colombia during the 1990s to reflect consistent annual probabilities of exceedance (or equivalent return periods for specific levels of loss) —these techniques were adapted for risk evaluation by evolving vulnerability functions. Using this approach, risk calculations resulted from the probabilistic modeling of hazard in order to estimate the damage a system might suffer. This may also be obtained in an analytical way, or based on empirical data. One advantage of this approach was that the results may be easily translated into potential losses, and might be then applicable, in terms of cost/benefit ratio, in the development of security standards, structural reinforcement programs, urban planning, and investment projects. The influence of the Pan-American Health Organization (PAHO), the Organization of American States (OAS), the United Nations Development Program (UNDP), the Inter-American Development Bank (IADB), and the World Bank, among others, improved risk awareness and the level of intervention in the vulnerability levels for hospitals, schools, lifelines, bridges, and other infrastructure. Unfortunately, the rate of growth of the problem is faster than the solutions offered, and not only good practice is necessary, but also an immense increase in intervention level.

The employment of damage matrixes, loss functions, fragility curves, or vulnerability indexes, including those that relate the intensity of a hazard event with the degree of harm or damage suffered by buildings, have allowed the estimation of scenarios of potential loss in case of future events such as floods, volcanic eruptions, landslides, tsunamis, and earthquakes in a number of places in different countries. This type of analysis of risk has been increasingly useful for land use or physical and territorial planning specialists in LAC countries, because it contributes data on hazards or risks as an ingredient for decision making processes.

The old 'risk transfer' approach employed by the insurance/re-insurance industry favored the post-2000 consolidation of a new paradigm for risk analysis of public assets, security, and trustworthiness of systems in some countries. This contribution of engineering and accurate sciences to the study of vulnerability, promoted the concept of vulnerability using probabilistic and actuarial methods. Risk modeling for the development of strategies of risk retention and transfer, as well as the design of financial instruments such as reserve funds, contingency credits, and catastrophe bonds, are being explored in Mexico, Colombia, and the Caribbean, where several countries created a joint insurance captive facility. Recently, multi-hazard risk evaluation and disaster risk indicator projects have been supported in Central America by the World Bank, and in most LAC countries by the IADB. These state-of-the-art projects are multipurpose, because their objectives comprise risk understanding, risk communication, risk reduction, and risk financing.

Doubtlessly, the contribution of engineering to the analysis of the resistance of physical structures meant an important change of paradigm regarding risk. However, though a more complete definition of risk was provided, the approach is still biased and too dependent on the physical and economic effects. Curiously, the methodologies developed by this approach resulted in actual risk estimations only in a few cases. In practice, physical vulnerability evaluation tended to substitute real-risk evaluation, which has remained as a secondary result.

These techniques allow for risk evaluation in economic terms by estimating the replacement cost of the damaged vulnerable system. It's even common to find, in the case of future loss scenarios, that the term 'social impact' refers only to the number of victims, both dead and injured. Despite the fact that this information is important for emergency preparedness and response, it remains as a restricted vision focused only on the applied sciences, with disregard of all other social, cultural, economic, and political aspects. Disaster, which is defined as the materialization of risk, has been restricted to a calculation of the losses represented by physical damage, and not, in a more comprehensive way, as the overall consequences suffered by society. Undeniably, this approach has been fostered by the notion that vulnerability can be construed as the exposure, or at best, the susceptibility to suffer damage, without any real reference to resilience; i.e. the capacity to recover from or absorb the impact.

On the other hand, beginning in the 1990s, disciplines such as geography, urban and territorial planning, economics, and environmental management helped strengthen the contribution of the applied sciences approach to disaster management in the region. 'Maps' are increasingly common due to a greater participation from geologists, geotechnical engineers, and hydrologists who contributed raw materials for the adequate identification of danger or hazard zones, according to their areas of interest in natural phenomena. Computer tools such as geographic information systems (GIS) have facilitated this type of identification and analysis in urban centers and watersheds of most LAC countries. However, excepting the case of seismic hazards, the vulnerability mentioned in this approach has normally been considered a constant when used for territorial planning purposes. This is based on the notion that the elements are located in hazard-exposed zones and thus, are automatically vulnerable. Many hazard maps have been converted mechanically into risk maps and considered as such, and vulnerability is taken as a constant and a mere function of the exposition of the system components. Thus, this approach continues to give paramount importance to hazard, and hazard is considered the most important, if not the sole cause of disasters. The use of GIS has reinforced the view that risk is something 'photographic' or 'frozen.' At best, the concept of vulnerability proposed by this approach is used solely to explain physical damage and other direct side effects. Seen from this perspective, risk has been interpreted generally as a potential loss, taking into account any possible damage.

Finally, starting on the 1990s, climate variability and change have been of special interest to meteorologists and researchers from most countries due to the effects of the El Niño Southern Oscillation (ENSO) phenomenon, and to the potential exacerbation of hazards such as hurricanes, floods, droughts, landslides, cold fronts, etcetera, in association to climate change. Unfortunately, these concerns have been translated once more, over the last years, into research efforts focused more on hazards and less on vulnerability and adaptation. For this reason, it's necessary to advocate an interdisciplinary effort in order to address vulnerability reduction from a comprehensive or integrated scientific approach, with the participation of researchers from the region trained in natural, applied, and social sciences.

4.2. SOCIAL SCIENCE RESEARCH: A BALANCE OF THE HISTORICAL DEVELOPMENT AND CURRENT STATUS

Before 1990, research efforts could be divided in two types, with two major influences. First, research promoted and developed mainly by North American scientists in the wake of major disasters in the region from 1960 onwards, and which analyzed their response and reconstruction strategies and goals (in particular those associated with the 1970, 1972, 1976, and 1985 earthquakes in Peru, Nicaragua, Guatemala, and Mexico, respectively; the 1982-1983 El Niño; and the 1964 and 1988, Fifi and Joan hurricanes). Examining the failures of a significant part of those initiatives, this type of research contributed certainly to the search in the region for innovation and improvement in response and reconstruction actions. However, little research was undertaken on the basic aspects of social risk construction and reduction.

The second source of inspiration came from Latin American, or Latin American-based researchers or authors, beginning in 1981. The 1980s failed Brady prediction in Peru, the 1983 earthquake in Popayán, the 1985 earthquake in Mexico, and the 1986 mudflow in Nevado del Ruiz, helped stimulate such research. Two topics dominated those limited research efforts, insights and reports. First, the topic of vulnerability was developed, which had an important effect on the risk paradigm used, and on putting an end to the former and dominant physical science paradigm for disaster interpretation. And, second, a number of studies were performed on the connections between disaster and development, and vice versa. Those studies underscored the importance of environmental and territorial factors on the conditioning of risk and disaster, specifically on hydrometeorological hazards. The incipient concern for vulnerability and development had critical importance in the later development of modern risk and disaster research and paradigms in the region. At the same time that this incipient social science research was done, natural sciences were in full swing, well financed, and increasingly geared toward disaster oriented initiatives. The Brady prediction and other real life disasters led to an increase in financing and attempts to predict and forecast events, both geological and meteorological. In addition, new natural science research and monitoring centers were established during the 1980s in several countries of the region. Before the 1990s, little effort was made to bring together social and natural scientists under a common research effort geared to reduce risk or disasters.

The start of the UN International Decade for Natural Disaster Reduction, in 1990, undoubtedly served to stimulate research and technological developments worldwide, and social scientists weren't slow to push for, and undertake more research, particularly in Northern Hemisphere countries, where an already well-developed research capacity existed. In Latin America, this event, plus a concern about the course that the decade would take, and the role attributed to social aspects and local inputs in its formulation, led to the creation of the Social Studies Network for Disaster Prevention in Latin America (LA RED) in 1992. Bringing together a mere 16 people interested in the social approach, this network grew significantly over the next ten years and had a major impact on the accepted wisdom on this topic, as well as on the development of conceptual and methodological research frameworks. Moreover, between 1993 and 2005 it promoted more than ten multinational, comparative research projects, which brought to light many interesting and innovative theoretical, empirical, and practical aspects. The advancement of notions about vulnerability and the social construction of risk, risk-environment-development interaction, small and medium disasters, socio-natural hazards, corrective and prospective risk management, and the actual concept of risk management and local risk management in particular, can be attributed basically to LA RED, since it developed new ideas, and adapted for the Southern Hemisphere and spread in the region some appropriate "Northern Hemisphere" lines of thought.

From the beginning, multidisciplinary and interdisciplinary principles have pervaded the concepts, methods, and ways of thinking of the LA RED members, which included from the start engineers, geologists, and ecologists interested in social science ideas and methods. The notion of "social construction of risk" that has permeated a major part of social science studies and discussions, rests on the idea that risk is built on the basis of physical events in which society, through different social processes (including exposure, vulnerability, capacity building, resilience, coping capacity, and perception), determines the final levels of risk, as well as the nature of the intervention undertaken in terms of reduction, mitigation, and prevention. The society-nature interface is a determining factor for examining, understanding, and intervening risk.

During the 2000s —in the post-Mitch, Vargas, and 1997-1998 El Niño era—, at a time when climate change issues and the call for adaptation strategies had increased substantially, the rate of social science research on risk and disaster promoted on an organic basis, actually dropped. However, at the academic level, and especially among undergraduate and graduate students, a larger number of dissertation theses in now under way. Such tendency may be explained by the impact of the demands for consultation work among different international and national agencies, and the impact that this had on the transfer of some of the region's more prestigious researchers, the lack of institutionalized research facilities for promoting social science-based research (no specialized research facilities have been established in the region during the last 20 years to undertake those research challenges from a comprehensive perspective), the lack of research funding, and the increased pragmatic and possibly opportunistic access to funds for climate change adaptation work, which some consider as competing with more traditional disaster risk-management issues.

Such tendency to a decline in organically-promoted and financed risk and disasters research comes at a time of ever increasing importance of the issue, and when the need for integrated research is becoming more evident, because the patterns of physical and social aspects that have an influence on risk are undergoing transitions and changes associated with global change in general.

With regard to climate change adaptation concerns, while most research is directed to understand changes in the climatic parameters, and the modeling of climatic systems is prevalent and increasingly funded, little has been done in regard to the analysis of changing vulnerability and exposure patterns, and their impact on adaptation. Moreover, due to the way in which climate change arrived to the scientific and social scene, with its early focus on understanding the processes by which change is brought about (carbon emissions, land-use changes, urban heat-island effects, etcetera), climate change research has tended to detach from disaster risk concerns. Institutionally, they are also dealt with by different agencies. This is quite inconvenient, since many researchers consider that climate change adaptation is, in many ways, the continuity of risk mitigation and prevention as seen by risk-management specialists who work on risks associated with normal climate variability. Much can be gained by integrating climate change and risk management issues, including the fact that much may be learned about adaptation, and the challenges it provides, by examining human responses and adaptations to ongoing climate variability, including such phenomena as the El Niño and La Niña.

5. RESEARCH PROGRAM

Regarding disaster risk, four different research and action subjects have been identified for this program which require the differential participation or interaction of natural, basic, applied, and social sciences in order to understand, design, and increase the effectiveness of prevention, mitigation, or response-based interventions.

First, the identification of significant, as yet uncharted and unmapped natural hazard processes and patterns, which could be associated with current or future risk patterns and disasters.

Second, understanding the factors and processes (both social and physical) that contribute to the social construction of risks, and to the ways in which risk is socially, territorially and temporally distributed.

Third, identifying ways to evaluate, measure or gauge risk objectively (actuarially), and the ways in which risks are socially analyzed; i.e., the way risk is given real social meaning, and a basis is established for decision making in favor of, or against risk reduction and control. Seen from the actuarial (statistical and mathematical) perspective, very high risk levels may be given low priority ratings by different social groups, due to the influence of social, cultural, economic, and/or political factors. Under certain conditions, the reverse may also be true.

Fourth, understanding decision making processes, and the real enactment or rejection of risk reduction and control measures, disaster preparedness, and response and recovery actions.

Although these four aspects or subjects and their subdivisions are different, they can also be seen as concatenated, so their final output, in terms of risk management, will be influenced by the inputs garnered from each type of process, and its contribution to the understanding and measurement of risk. When seen from the perspective of disaster risk, and disasters *per se*, the more definitive or conclusive of these subjects relate obviously to the decision to act, reduce or control risk. Namely, the structure and configuration of research undertaken on the evaluation and assessment of causal factors should be directed optimally by an interest in the promotion of adequate decision making, and the identification of risk management needs and options. Of course, this doesn't mean that basic science, with its latent positive effects on understanding and decision making, shouldn't be encouraged.

The three "knowledge" demands or contexts (new natural hazard identification and patterns, risk development processes, and risk evaluation and assessment) are absolutely fundamental in achieving decision making, and must be seen as a comprehensive part of it.

The present research program uses as its basis the fourfold division of research needs established above. Some of the challenges and limits, as well as the methodological and research questions related to each of those needs, are presented below. In the future, they should serve as guidelines for project formulation under the auspices of the current research program initiative. At the same time, a short series of generic research topics, which are compatible with the four research areas identified above, will be presented in the following section. While those topics are seen as priorities by this ICSU committee, they are not meant to be limiting, but rather indicative of a series of areas of interest that should be facilitated for future research by the present research program initiative.

5.1. UNKNOWN, IGNORED, OR FORGOTTEN NATURAL HAZARDS AND THEIR PATTERNS

Research and monitoring undertaken by geosciences establishments over the last 50 years in particular, have helped increase notably our understanding of the natural processes and events that may be associated with risk and disasters, or be considered as a factor in the risk and disaster equation. However, past disasters have constantly reminded us that there are many significant potential hazard contexts that remain unknown or unmapped, or that have been simply wiped out from human memory by time and social processes. The 1983 and 1991 earthquakes in San Isidro and Limón, Costa Rica; the 1993 tsunami in Nicaragua; the hurricane Mitch and its effects and route over Central America; the Vargas mudslides in Venezuela; and the Chaitén Volcano eruption in Chile, are examples of disasters in which such events, due to time and inaction, were simply uncharted, unexpected, or erased from human memory and consideration. This indicates that still there's a real and significant need to promote new studies on natural processes and events and their patterns, which may serve as important inputs for planning and management. Given the size and extent of our continent, and the number of possible uncharted physical processes and occurrences, one major challenge is how to determine research needs and priorities in a way that is significant for the risk and disaster problem, and not only for science in general. Another problem associated with hazard patterns is the need to downscale, to the local or micro levels, most of the existing hazard information. Much work is required in the region on this area oriented to the use of hazard information in local planning and community-based schemes.

Uncharted events are one significant aspect. However, there's another problem with events that, having been mapped in the past, were then forgotten or misrepresented for social or political reasons. Research must contribute to our understanding of such processes. The recent Chinese earthquake revealed that the affected area hadn't been included on any map of high-risk areas. Likewise, the Limón earthquake didn't appear on any risk map, despite the fact that later analysis showed that the area had been affected earlier by same-level events, during the 19^{th} and 20^{th} centuries. Historical data on events such as the Vargas mudslides have also been traced subsequently.

5.2. UNDERSTANDING THE SOCIAL CONSTRUCTION OF RISK

Risk is the product of interactions, in time and space, between exposed and vulnerable human populations —including their livelihoods and support infrastructures—, and potentially damaging physical events. Therefore, in addition to a thorough understanding of the diverse natural processes that generate potentially damaging physical events (which are the subject of diverse natural and applied sciences, such as seismology, volcanology, hydrology, meteorology, civil engineering, etcetera), having a better understanding of risk requires, as a minimum:

- Knowledge of the processes by which human intervention in the natural environment leads to the creation of new physical phenomena or events, and potential (socio-natural) hazards;
- Knowledge of the processes by which people, property, infrastructure, and goods are exposed to potentially damaging events —i.e., understanding location.
- Knowledge of the processes that contribute to the multidimensional vulnerability of people and their livelihoods, as well as any increases or decreases in such social condition —i.e., understanding the allocation of social and economic resources in favor of, or against the achievement of resistance, resilience, and security.

5.2.1. New hazards

In the case of new events and hazards associated with human intervention in the environment (deforestation that causes greater landslide and flood risks; carbon emissions that lead to climate changes, and increase climate-related hazards; mangrove destruction that increases exposure to wave/tidal action and coastal erosion with negative impacts on people), research must elucidate the reasons behind the type of human interventions undertaken, the limits and opportunities offered by the environment when faced with such interventions, and the options or alternatives that may exist for achieving similar, and legitimate, social or economic goals without such adverse environmental impacts and results. Knowledge must also be increased on the existence, location, intensity, and patterns of such events, from those generated locally, to climate change-related events. This means a new map of hazards that goes beyond events or hazards normally considered as "natural."

From the research perspective, natural sciences can provide a basic platform to understand intrinsically delicate, and "quasi-stable" physical processes (in terms of geomorphology, ecology, etcetera), whereas social science can provide an understanding of the social, economic, cultural, and political basis for the types of intervention experienced. Then, a basis can be established for alternative forms of intervention that maximize social and economic welfare, but without leading to a loss in the productivity and stability of the supporting environment.

From the information and management standpoint, a major challenge for natural sciences is making available, to both individual and collective decision makers, any relevant and politically appropriate knowledge and information on physical processes, in such a way that consequences are transparent and alternatives may be recommended. Undoubtedly, this will require the active and coordinated participation of all social sciences in aspects related to the overall social communication of knowledge, and the design of politically expedient strategies for the diffusion of information and knowledge among decision makers.

As may be easily appreciated, the type of interactions and necessary coordination between social sciences, and basic, natural and applied sciences, may vary when dealing with research or information management.

In the first case, although the types of research fostered by natural and social scientists clearly aim in the same direction (understanding the factors that contribute to risk, and the generation of risk factors), the goal of research can be seen as essentially "autonomous," and information and knowledge generated by the development of basic natural and social science research doesn't require major collaboration or interactions, at least beyond those required by natural and social sciences themselves (e.g., understanding the landslide and flood mechanisms generated by human intervention in the environment will probably require the collaboration of meteorologists, hydrologists, and other earth scientists; likewise, understanding the patterns of forest clear cutting on slopes will require the collaboration of economists, geographers, sociologists, and anthropologists).

On the other hand, every time we widen our perspective to deal with research methods, this conclusion on interactions and collaboration between disciplines should also be reconsidered, besides the mere objectives and goals. Thus, whenever participatory research methods and stakeholder involvement are considered as necessary options for the study of environmental change processes, the need for closer interactions and understanding between social scientists, and natural, basic and applied scientists becomes obvious.

In the case of information and knowledge diffusion among decision makers, the stakeholder principle stated above still holds as a rule, but it must be complemented with the collaboration of social sciences in the development of information strategies that make "hard" scientific information available in accessible, easily understandable, and politically and socially expeditious ways, to decision makers and the public.

5.2.2. Understanding location and exposure to damaging physical events

If human settlements and economic resources weren't placed in potentially dangerous locations, no problems of disaster risk would exist. In fact, land use and territorial planning are key factors for risk control and prevention.

However, due to the intrinsic and fluctuating hazardous nature of the environment, as well as our growing populations, diverse demands for location, and the gradual decrease in safe terrain availability, among other factors, it's almost inevitable that people and human effort are frequently located in potentially dangerous places. In fact, given that the chosen places are often endowed with natural resources, and exposed periodically to certain hazards (volcanoes, steep slopes, flood plains, etcetera), location in hazardous areas is, in general, all but inevitable. Therefore, the key to good land use and territorial planning or other forms of rationalizing location, is minimizing any unnecessary exposure and vulnerability to damaging events. Whenever exposure to probable future events is considered impossible to avoid completely, land use planning and location decisions must be accompanied by other structural or non-structural methods in order to prevent or mitigate risk. Land use plans must be based on location, and vulnerability reduction strategies and methods.

Clearly, the starting point for adequate land use and territorial planning is knowledge about the natural environment, its resource and hazard base, its carrying capacity, and its limits for human use, among other factors. At the same time, natural and basic sciences may provide information and knowledge about the limits of natural environments faced by diverse land use options and processes, and the potential for new human-induced hazards —e.g., degradation of aquifers due to urban growth; increases in runoff rates due to the use of asphalt and concrete, and the needed urban flood controls; and possible local climate changes due to urban sprawl and the heat-island effect.

From the social science perspective, location is the product of different economic, social, cultural, and political reasons, where information on land's physical composition, carrying capacity, growth limits, etcetera, are "data" filtered by social criteria, and fast-tracked or not according to specific interests and social, economic, and political calculations and needs, among other factors. The diversity of possible scenarios may be illustrated by two extreme cases at the individual or family level.

First, financially well-off people who may settle intentionally in areas known to be exposed to potentially destructive events such as earthquakes and forest fires, due to the recreational value of such locations, where they "reduce" or "transfer" risk through the use of safer building techniques, and social and economic protection mechanisms such as preparedness, emergency plans, and insurance policies.

On the other hand, very poor families who settle in highly hazardous areas due to their lack of access to formal realty markets and safer terrains, where the risk of disaster is balanced by the hardships associated with everyday life. Frequently, this means that even after being offered a better relocation option, they refuse to move due to their access to other local livelihoods resources, as well as their cultural or historical ties to the land. All other sectors of society are located between these extremes, and therefore, have different reasons to settle in a certain place.

From the governmental standpoint, although hazard-factor control should be an intrinsic part of governance, it is common knowledge that, in fact, local and national governments contribute enormously to unsafe location and greater vulnerability. The granting of building permits in restricted areas, and the provision of basic urban commodities in areas highly exposed to hazards, are two mechanisms that "institutionalize risk" and, in the second case, form part of what may be called "implicit" urban policies. In other circumstances and places, governments adhere strictly to land use planning and hazard control location principles. Obviously, understanding such diversity of scenarios and decisions is an intrinsic challenge for social science research.

As in the study of processes leading to the generation of socio-natural hazards, the interaction between natural, basic and social sciences in gaining an understanding of location and exposure may be, at times, a series of sequential inputs where the social interpretation of location, as well as the search for control, are based on knowledge about the "natural" location limits, and the ways in which human intervention can change the nature of the environment and the hazards it creates. In the worst scenario, location isn't based on any real knowledge of the environment, and/or its settlement and use limits. Under some circumstances, this is due to lack of information and knowledge about a particular environment, but in other cases it's the result of an inadequate diffusion of information among family leaders or collective decision makers. One of the major new problems for risk and disaster control, in our future globalized and highly mobile world, will be the location of new enterprises and human activities in unfamiliar environments. All these topics deserve more research efforts that involve social sciences, and natural and basic sciences alike.

Seen from a more interactive perspective, but always regarding research methods, stakeholder participation, and mechanisms for information and knowledge diffusion, more interaction between sciences may be foreseen and planned if we aim to understand and influence location decisions. And a lot of the necessary information will be filtered, inevitably, by legal requirements and demands. Thus, one critical aspect of information generation and use will be the way in which such information is made available to the primary decision makers, whether collective or institutional (particularly from the public and private sectors). Another issue relates to the information which is affordable or accessible for secondary decision makers at the social and family levels. For instance, when we visit a certain shopping mall, how much information is directly available to consumers about internal or immediately external hazard factors? Or when choosing a certain school or college for our children, how much do we know, as "educational consumers," regarding the hazards posed by the facilities? Likewise, when we plan to purchase a house, how much do we know, as potential buyers, about local hazards and the level of structural safety of the house on sale? Clearly, whenever social communication and democratic access to information are critical factors in helping reduce risks, the interactions between social sciences and natural and basic sciences are crucial.

5.2.3. Understanding vulnerability

Seen from a social or anthropocentric viewpoint, "vulnerability" refers essentially to the tendency of humans and their livelihoods (which may be analyzed from the individual, family, group, local, regional, national, or international perspective) to suffer damage and loss when impacted by single or diverse physical events, and to confront reconstruction and recovery problems. Understanding vulnerability requires an analysis of the context (physical, institutional, social, economic, etcetera) and the characteristics and structures of human groups and their livelihoods, which predispose them to damage, losses, and recovery difficulties. Explanation of vulnerability constitutes a fundamental part of its definition, and in such explanation intervene several aspects of physical, technical, social, economic, institutional, and organizational nature, which require the presence and interaction of diverse natural, applied and social sciences.

Although one can accept that life is generally associated with intrinsic or innate levels of vulnerability, when risk and disaster studies are concerned, vulnerability and all its facets, factors, and levels should be seen as the result of defined social processes. In other words, vulnerability is the most evident manifestation of the social construction of risk. Only by dealing with the socially constructed elements of vulnerability, we may talk about the aspects that are subject to social intervention and change. Intrinsic or innate factors that contribute to vulnerability are, by definition, inherent and, in most cases, unchangeable. Therefore, they aren't subject to risk-management mechanisms beyond those associated with increases in awareness, education, and knowledge about security limits when faced with certain physical conditions (a meteor of a few kilometers diameter impacting the Earth, a paroxysmal volcanic eruption, or an upper scale earthquake are examples of exceptional events in which all life on the planet would be highly "vulnerable," regardless of the risk-reduction practices that could be imagined or in place).

Vulnerability is the result of different social and environmental processes, and the characteristics and conditions associated with them. It's a condition that relates to a concrete hazard context and, therefore, is "determined", delimited, or contextualized with reference to distinct and delimited physical events. In other words, one isn't vulnerable in general (although there are what could be called "general vulnerability factors"), but rather vulnerable when faced with determined hazard conditions. Thus, vulnerability related to earthquakes isn't necessarily the same vulnerability associated to hurricanes, droughts, or forest fires. Likewise, vulnerability used in reference to multi-hazard contexts isn't the same as the one associated to a single hazard exposure. This simple affirmation implies that all vulnerability analyses or studies, as well as any interventions aimed to reduce or control vulnerability, must be based on a thorough understanding of the nature of any potentially damaging physical event that threatens different zones and human populations.

Here, one of the outstanding questions relates to the types, levels of sophistication, forms of expression, and delimitation of physical factors required for different types of vulnerability analysis, and the methods used to get such information, which can range from a community-based hazard and vulnerability analysis, to a more formal, sophisticated, and modern scientific research. Once again, this implies that the methods for generating and diffusing information among interest groups and stakeholders are questions and practices as relevant as the generation of scientific information itself. Wherever the final objective of research is social improvement and change, information without communication is of little use.

While accepting this general principle related to the hazard-specific nature of vulnerability, it's also clear that certain factors, such as poverty and lack of social networks, capital and support mechanisms, will affect vulnerability levels irrespective of the type of hazard context; i.e., they are non-hazard dependent. Clearly, this type of generic factor is different from the hazard-specific factors, and assumes a different position in the intervention equation and the nature of risk-management processes. The existence of such factors can be clearly related to what has been called "deficits in development," and show evidently that research on vulnerability and risk cannot be separated from a consideration of the development patterns and models employed in different contexts and historical moments.

5.3. MEASUREMENT OF RISK: RISK ANALYSIS AND INDICATORS

Disaster risk is manifested as the probability of loss and damage in the future. Risk is apparent, latent and evident, and may be measured if enough knowledge exists or can be generated about the presence and magnitude of the diverse risk factors. To the extent that such information exists, an objective actuarial type of measurement or evaluation (equivalent to the evaluations that insurance companies use to decide on catastrophic risk or health insurance rates for individuals or collectivities) may be attempted. Subsequently, when informing decision making processes, such objective actuarial risk must be subjected to considerations on perception, social, cultural, and economic estimation —namely, an assessment.

Such actuarial measurement, and the subsequent creation of risk indicators, must be based on an understanding of the mechanisms by which risk is constructed (see previous section) and on the existence of adequate, objectively verifiable, and measurable "hard" physical, and "soft" social information. That is to say, information on physical events and hazard contexts, on factors contributing to vulnerability, and on aspects relevant to location and exposure, are requisites for risk evaluation. Risk evaluation can't take place without this diverse information base resulting from natural, basic, applied, and social science sources, and worked in a comprehensive fashion from a common understanding of risk and its components.

"Hard" attributes or factors include information on such aspects as: potential physical phenomena, their magnitude, intensity and return periods; the physical features of places; the characteristics of building materials and techniques; the value of installed infrastructure and production means. "Soft" attributes or factors include information on: social, economic, and political variables that affect location and vulnerability; information on attitudes, beliefs, and perceptions; and information on levels of preparedness and human resource capabilities in general.

While much information may exist for many places worldwide, we still lack in general much basic information at a large scale of resolution, both on hazard and vulnerability factors. This is particularly true for developing and emerging economies. The challenges for social and natural sciences are still enormous in regard to basic research and information gathering. Given the large number of communities at risk in any hazard-prone area, a challenge exists not only with regard to information as such, but also to the methods by which such information is and may be compiled. Inevitably, this gives way to discussions and considerations about the participatory, artisan or traditional knowledge bases, as fundamental, complementary measures to formal scientific research.

The development of easily accessible and understandable indicator systems is also a challenge when dealing with local or family decision makers, as opposed to national governments and the private sector. Understanding information is a first indispensable step in fomenting adequate risk reduction and control for decision making at different levels. Thus, for example, the type and level of information relevant for a national governmental sector agency will be different from that required for local mayors, planning offices, or construction companies. Dealing with these different needs and levels requires a different way to integrate natural and social science aptitudes and methods.

5.3.1. Assessing risk: An immediate prelude to decision making

Although clearly related, evaluation and assessment of risk are two different but sequential and related aspects of relevance for disaster risk management. Whereas evaluation implies the maximum objectification of risk in terms of probable losses and damages, assessment requires placing in perspective such losses in terms of the general life system and the goals of the affected or interested parties. This placement in perspective can be seen from an economic, social, cultural, historical, lifestyle, or political angle. Significant risk (one that requires searching and finding a solution) will differ as a notion according to the different social and psychological variables that operate in different social settings. An understanding of these factors is critical for understanding risk construction, and also in regard to the opportunities and options that exist for risk management mechanisms.

Mechanisms for risk assessment vary from the strictly formal, to the informal and subjective (and yet, scientific). Thus, while a government or private company may engage in cost/benefit analysis in order to substantiate its decision making, studies also show that such organizations employ less "formal" measures, and that their positive or negative decisions rely on assessment processes based on strictly political or "emotional" values (the notion of blame-reducing policies fits here). Individuals and families will probably assess risk in varying ways, according to circumstances, income level, social class, etcetera.

Assessment criteria will vary from group to group, and from individual to individual. Poor and very poor families and communities will always go way beyond "assessment" methods and processes that take disaster risk factors as their starting point. Therefore, for instance, where poor communities reject relocation to "safer" areas when offered this option by local governments, NGOs, etcetera, such rejection is rarely based on strict evaluation of disaster risk, but rather on a comparison between the economic, cultural, social, and historical built-up gains of the new location, and the advantages of staying put. Specifically, disaster risk is compared to everyday risk aspects in order to substantiate decisions.

With regard to risk assessment, it's clear that many techniques are firmly based on social science methods and practices —they imply social and economic assessment in some way or another, whether formal or informal, objective or perceptive. However, regardless of the technique or social criteria used as a base for the assessment, this is always undertaken in a framework typified by an existing, objectively identifiable, hazard context. The nature of the information available on these contexts, the availability of easily accessible and understandable information, the accuracy with which such information is produced, and the accuracy of risk predictions, are all fundamental assessment parameters and inputs. Thus, assessment implies, inevitably, a consideration of information, data, and the ways these are generated, the means by which information is more easily accepted and trusted by users, the mechanisms for user appropriation of information, and the methods used for its generation, among others.

As a result, even where assessment is a social technique, its inputs, and the methods used to achieve it, are inevitably interdisciplinary. Active participation of natural, basic and applied science practitioners in the process of assessment and understanding of this, can only lead to a more ample understanding of how such processes are enacted and, therefore, of the variables considered for decision making when these go beyond a simple scientific "fact." And this could lead to an accumulation of improvements in the methods of data collection and diffusion.

5.4. DECISION MAKING FOR RISK MANAGEMENT

Previously, we suggested that the overall primary objective of research, analysis, understanding, evaluation, and assessment should be the provision of information and knowledge that facilitates and promotes decision making in favor of risk reduction and control. In this sense, the three previously discussed aspects can be seen as part of the needs and processes of decision making. However, decision making as a theoretical process, and decision making in terms of real life and decisions, may be two different things. Unfortunately, we know very little about the real processes that have informed many significant decisions in regard to risk management practice. Moreover, we also lack much in terms of understanding the process of "non-decision." In other words, the process by which actions were ignored or rejected by decision makers is rarely known. Rather, they tend to be the subject of criticisms and superficial comments about such things as lack of political will, ignorance of science by decision makers, etcetera.

As an object of scientific enquiry, decision making may serve to put in perspective the three research and interdisciplinary collaboration areas previously discussed. The study of the decision making process in successful and unsuccessful cases, in different social levels and different societies, both synchronically and diachronically, among other things, could be of enormous help to foster a better understanding of the socio-natural interface, and the ways in which knowledge advancement is fostered by closer conceptual and practical interactions between the disciplines, as well as their connection to information users and direct stakeholders in the decision making process.

6. SOME PRIORITY SUBJECTS FOR THE RESEARCH PROGRAM

In this section, and according to the priorities established by the ICSU planning committee, we'll identify a series of subjects that could or should be promoted as projects for the first stage of the program. As mentioned at the beginning of the previous section, those subjects are indicative, but not exclusive, and we hope that projects will be promoted for the full range of options and needs identified in the preceding section.

6.1. METHODOLOGY FOR NATURAL AND SOCIO-NATURAL HAZARD MAPPING AND INTEGRATION IN PLANNING PROCESSES FOR SMALL TOWNS AND VILLAGES IN LATIN AMERICA (SUBJECT 5.1)

In general, villages and small towns in Latin America and the Caribbean lack the environmental knowledge necessary for natural and socio-natural hazard mapping. Research is required to design methodologies for the evaluation of available cartography and information, and to implement the necessary steps to reach a basic level which will permit an acceptable appreciation of natural and growing socio-natural hazards, and the recommendation of further actions.

The product of such efforts should be useful to convince both, local inhabitants and authorities, that natural and socio-natural hazards must be considered as an important aspect of local planning, and that further improvement of hazard and vulnerability evaluation means investing on the future well-being of the people. A by-product of the development of projects in this thematic area could relate to water availability, access to building materials, and localization of adequate sites for garbage disposal, actions which may be considered as health-hazard protection for the inhabitants.

6.2. TOWARDS BETTER HILLSIDE CONSTRUCTION CRITERIA (SUBJECT 5.2)

Many urban areas in LAC have significant settlements located on steep terrains. All but a handful of the Caribbean islands are mountainous. For instance, over 60 percent of Jamaica is occupied by mountains. In Grenada, 45 percent of the island's area has slopes which vary between 21 and 30 percent, and 25 percent of the island has slopes in excess of 30 percent

Steep slopes are inherently hazardous areas for human settlements. And there's also the question of aesthetics. Current hillside low-income settlements in urban areas are unbelievably ugly. Another sore point is their unhealthy living conditions.

Although much work has been done by several agencies on specific aspects of the problem, there's still the need to consolidate, in a single document or set of documents, all the expert's guidelines for safe construction on steep slopes. This requires a multidisciplinary approach involving (in random order): anthropology, sociology, land-use planning, forestry, geology, seismology, geotechnics, environmental impact assessment, hydrology, infrastructural engineering, architecture, structural engineering, earthquake-resistant design, wind-resistant design, and public health.

The subject should be developed as a background for specific and practical guidance on all aspects of hillside development, based on a presentation of fundamental scientific issues. The ultimate goal is providing all stakeholders with detailed tools for the safe, healthy, and visually pleasing development of hillside communities.

6.3. DATA COLLECTION FOR NATURAL HAZARDS (SUBJECT 5.1)

The engineering and planning sector requires more and better information for the rational design of drainage systems, and wind and earthquake resistant structures. In past centuries, rainfall information was routinely collected by farmers in many parts of LAC, but now such data collection activity isn't so prevalent. In many countries, meteorology is driven by the needs of civil aviation. Extreme wind events are infrequently and not always adequately measured and recorded at ground level. There are insufficient anemometers installed in the region. The recording of land accelerations, velocities, and displacements caused by strong earthquakes is rarely achieved. There are few installed and maintained strong-motion accelerographs in the region.

This thematic area must project and promote the establishment of data-recording infrastructure, and bring to conclusion the long-term commitments from research institutions and other agencies for the maintenance and monitoring of recording instruments. The gathering and storing of previously collected data on rainfall, wind speeds, and ground movements from the LAC region must also be a central objective of this thematic area.

6.4. DISASTER RISK MODELING PLATFORMS (SUBJECT 5.3)

Disaster risk modeling platforms are modular systems of simulation that allow to evaluate consistently hazard, vulnerability and risk at local, regional and national levels, by using appropriate levels of resolution according to well-defined purposes (land use, cost/benefit analysis, preparedness, mitigation measures, investment, and financial protection). The core of these platforms should allow us to select the type of hazard (earthquake, hurricane, wind/surge, flood, landslide, volcanic eruption, tsunami), as well as its scale and resolution according to the quality of the information available, and the purpose of the evaluation. A major objective of these platforms is to develop a risk evaluation and communication tool to facilitate the socialization of risk assessment at the local, regional, national, and international levels, and to increase policymaker's awareness about the exposure levels of each country, as well as provide them with open source tools that help them design risk management strategies. The multi-risk modeling platforms should have an open architecture and be dynamic, so they allow wide distribution, and future updating and improvement by the users through an Application Programming Interface (API). The software platforms should be hosted in a manner that is widely accessible, including websites for countries and/or regions; e.g., Central America, South America, the Caribbean. Besides, the platforms should be compatible with Google Earth, Microsoft Geo, NASA World Wind, or any similar free tools available for geospatial data visualization. The idea is to allow online users (i.e., communities with shared interests) to enter information about visible structures on high resolution GIS maps. This platform would permit the development of an Atlas of hazards and risks (using probabilistic data; e.g., probable maximum loss, average annual loss, based on the loss exceedance probability curve of exposed sets of assets) at any scale for each country, depending on the available information, with notes on potentially suitable uses and assumptions, and a structure similar to the Wiki approach in order to facilitate the use and contribution of scientists by means of an open architecture and source models.

6.5. INDICATORS OF DISASTER RISK AND RISK MANAGEMENT AT THE SUB-NATIONAL LEVEL (SUBJECT 5.3)

Systems of indicators are proposed to measure risk and vulnerability using relative indices at the sub-national level. From the interdisciplinary perspective, this means considering "hard" and "soft" variables related to the impact of the events, and the capacity of society to sustain, and cope with the impact and implications of these effects. The aim would be to provide regional and urban center decision makers with access to the information that they need to identify risks, and propose adequate disaster risk management policies and actions. Such systems of indicators should allow the identification of economic and social factors that affect risk, and risk management, as well as comparisons of these factors between units of analysis (provinces, departments, urban districts, and so on). The goal of this research would be to design methodologies of risk understanding and communication, and apply them to a wide range of sub-national areas in order to identify analytical factors (i.e., economic, social, resilience, etcetera) to carry out an analysis of the risks, and the risk management conditions for each country. Besides, the systems of indicators must allow holistic, relative, and comparative analyses of risk and risk management, as well as the creation of risk management performance benchmarks in order to establish performance targets to improve management effectiveness. The systems' main advantages would be their ability to disaggregate results and identify factors that should be priorities in risk management actions, while measuring the effectiveness of those actions. The main goal is to facilitate risk understanding and the decision making process (risk reduction and risk financing). In other words, these systems will allow the use of a general measuring "ruler" to compare and benchmark the results. The goal of the models isn't only to "reveal a truth", but rather to provide information and analyses that can "improve decisions".

In addition, the systems of indicators should help fill an important information gap for sub-national decision makers in different sectors such as finance, economics, environment, public health, territorial planning, and housing and infrastructure. The methodologies should provide tools for monitoring and promoting the development of risk management capacities. Since the data would be comparable across units of analysis, this should allow policymakers to gauge the relative position of their location, and compare its evolution over time.

6.6. DECISION MAKING AND RISK MITIGATION AND PREVENTION (SUBJECT 5.4)

Risk mitigation (corrective) and risk prevention (prospective) measures are used when decisions are taken to implement different schemes and practices. Such decisions may be taken by organizations, governments, groups, or individuals. Making a decision requires information, and the decision must be made in a context that encompasses all the deciding actors. Our knowledge of decision making associated with disaster risk mitigation and prevention is scarce in LAC. And we don't know why this is so, or under what circumstances or motivations, or based on what information and parameters. This is also true for national governments in regard to national policies, and for local governments in regard to local plans and specific actions such as reinforcement of existing structures, building of dams, risk considerations in project planning processes, etcetera.

Having an understanding of the complexities of decision making on different levels in various countries, especially in relation to both prospective and corrective mechanisms and interventions, would greatly help actors understand how things get done, and how to get things done. Understanding the interactions and roles of natural and technical science experts, in comparison to policymakers, economists and other social science-based actors, would also help both sets of actors comprehend how they have collaborated, and how they could collaborate in decision making. Our understanding of decision is often incorrect, and we assume that certain processes, such as cost/benefit analysis, are significant in all decisions taken by public or private sectors. This isn't necessarily true.

This thematic area will promote studies on decision making processes in different risk contexts. Both successful implementation and failed proposals will be analyzed. The areas of research will vary from local governments who incorporate risk management tools, to national governments who build dams to protect communities; from decisions to modernize and reinforce buildings, to decisions to introduce risk analysis in public investment plans. Selection of case studies will cover a range of countries, contexts, situations, and sectors.

6.7. CLIMATE CHANGE ADAPTATION AND DISASTER RISK MANAGMENT: UNDERSTANDING, JOINING, AND LEARNING (SUBJECT 5.2)

Disaster risk management concepts and experience have been developed in the light of historical and projected future contexts of hazard and vulnerability. When dealing with climate related aspects, this can be seen in the light of hazards associated with what may be called "normal climate variability." On the other hand, adaptation to climate change has been developed as a notion that sought practice through other professional and institutional modalities, as if it were a separate and discrete area of knowledge, directed to future climate conditions influenced by human intervention, using theoretical scenarios for up to 50 or 100 years in the future.

This "false" separation of two clearly related topics is the product of historical and institutional reasons, and must be solved in the interest of advances on both risk areas, i.e., now and then. Clearly, the central problem for both communities is social risk associated with physical hydrometeorological hazards, the ways in which new hazards or more extreme versions of ongoing hazards interact with exposure and vulnerability conditions to produce greater risk in society, and the ways to reduce or control such risk.

Disaster risk management has developed mainly in regard to existing risk —corrective risk management. However, the line of thought developed more recently with regard to prospective risk management (i.e., anticipating and controlling future risk) is clearly of absolute relevance to the so-called adaptation to climate change issue, and can be used as a bridging concept between the two areas of consideration and enquiry.

On one hand, we must encourage research efforts which clearly identify changes in the semantic, spatial and temporary patterns of hydrometeorological hazards, and their accompanying exposure and vulnerability factors, including mostly evidences of such changes associated with climate variability and climate change during recent periods (under the notion that climate change is under way). And regarding the ongoing processes by which human populations located in areas where climate is changing visibly today, and which have been required traditionally to deal with climate variability extremes, have dealt with such contexts through historical or ongoing prevention, mitigation, risk-reduction, or adaptation schemes. Knowledge about ongoing processes of risk reduction and control will help enormously to understand and promote "adaptation" in the more distant future, within the overall context of more wide-ranging global change. The options for such adjustment in the future rest on our ability to deal with today's problems, and control significantly the existing exposure and vulnerability trends, many of which, though not all of them, are associated with poverty.

7. SUPPORTING ELEMENTS FOR THE RESEARCH PROGRAM

7.1. CAPACITY BUILDING

Experience and support for training and education in the region has concentrated mainly on disciplinary fields where physical and applied sciences lead the way, and social sciences have made important gains and advances over the last 15 years. Seen from the disciplinary perspective, and the role that this plays in education and training for risk and disaster work, the region possesses a fundamental core of well-trained people, however insufficient in numbers in many countries. Clearly, there is a need to further promote and enhance existing capabilities at the disciplinary level, and to encourage an extensive incorporation of risk-related aspects in a wide range of disciplines at the undergraduate and graduate levels. This isn't necessarily something that should be a priority for this ICSU program, given the existing mechanisms to support and promote disciplinary advances.

Rather, what should be supported through the present program is the multi-, inter- and transdisciplinary research challenge, in order to offer mechanisms for promoting the type of research method indicated in the present report. In this sense, the program, as well as the financial mechanisms it may develop, should be instrumental in the establishment and promotion of educational and training modalities and mechanisms that promote holistic, integral, inter- and transdisciplinary approaches to research and problem formulation.

This may be achieved in a number of ways.

First, research projects supported by this program should be required to incorporate on-site mechanisms that support and strengthen capabilities for interdisciplinary collaboration and work, which could have a secondary effect in teaching programs led by project researchers. Incorporating young researchers in projects and exposing them to interdisciplinary protocols, would be a secondary effect.

A second, more formal and institutionalized approach, would be the promotion and support given to the establishment of one or more interdisciplinary research and teaching facilities, linked to existing national or regional institutions in the LAC region. An ideal mechanism would be the promotion of holistic educational opportunities through the involvement of students in research projects that are complementary to any formal educational opportunities offered.

A third complementary mechanism would be giving support and incentives to graduate courses on holistic and comprehensive risk-management principles, taught in established institutions.

The present program, which is backed by the ICSU, should search to support such initiatives, both financially and in terms of human resources.

7.2. POST-MORTEM OR FORENSIC STUDIES OF DISASTERS IN THE REGION

The most valuable laboratory for the study of risks and disasters is found in the impacts of real events. To learn effectively from these events, research teams, protocols and logistics must be developed well in advance, and all necessary institutional arrangements must be negotiated and in place. Although post-event diagnostic surveys are carried out in the region, these are done in an uncoordinated way, and the lessons learned from them are insufficiently shared, and only rarely reviewed by peers.

There is the need to establish a mechanism for post event diagnostic surveys that allows to understand the fundamental physical and social processes that led to risk and disaster; key issues from structural performance during earthquakes and hurricanes which have implications for public health and social and economic impacts; social responses to disaster, and; processes leading to recovery plans and procedures. Post-event diagnostic surveys should be multidisciplinary, and support analysis for the improvement of mitigation planning, regulation and investment. Results of the diagnostic surveys should be shared with the professional and educational communities, and with other fields by means of the most appropriate and efficient information technology.

Such a facility, and the information it provides, would be the basis for establishing a permanent evaluating committee on risks and disasters in the region, whose work and results could serve as a pressing factor to initiate changes in practices and policies within the region.

The idea of forensic studies is complementary to the notion recommended by the ICSU's global program, which was created by its Paris office and headquarters, and now is awaiting final approval by the ICSU hierarchy at the next conference in Mozambique.

8. RECOMMENDATIONS ON FINANCING FOR THE RESEARCH PROGRAM AND ASSOCIATED SUPPORT ACTIVITIES

Two basic modes may be suggested:

First, based on the approved content of the present program, block financial support may be sought from existing international organizations that invest money in research and training. Multi-institutional support for the program should be sought from research promotion organizations, and from international development agencies interested in the risk and disaster issue. For the first phase, a minimum of 10 million dollars should be sought for research, plus a complementary amount to promote capacity building in the region. Separate funds should be also sought for post-mortem/forensic studies, and for the establishment of an ICSU-promoted permanent evaluation committee on risk and disaster in the region.

Second, the ICSU, with its contacts and presence in national research support committees and institutions in various countries —for example, CONACYT—, should seek an annual allocation of financial resources for the research and training goals at the national level that would complement the regional, comparative, and integral goals at the global level.

9. MECHANISMS FOR GUIDANCE AND OVERSIGHT OF THE PROGRAM

The program must have a coordination and support office located in a renowned academic institution, or within the ICSU's structure *per se*. Regional support facilities could be another option.

A work team consisting of a program coordinator, and a maximum of two support officers with social and physical science backgrounds, along with the necessary administrative and secretarial support, would promote, monitor, control, and evaluate the program's operation and progress. Research projects should not exceed three years. Wherever support should be available for educational and training activities, as well as for the forensic studies component, additional staff would be necessary.

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GLOSSARY

ANTHROPOGENIC OR ANTHROPIC HAZARD: A latent threat associated with economic production, commerce, transport, and consumption of goods and services, and the construction and use of infrastructure and buildings. These comprise a wide range of threats, including different types of water, air, and land pollution, fires, explosions, spills of toxic substances, accidents in public transport systems, the rupture of dams, building collapse, etcetera.

CORRECTIVE RISK MANAGEMENT: A process aimed at reducing existing levels of risk within society. Examples of corrective management activities or instruments include the construction of dams to protect settlements located in hazard-prone zones, the seismic reinforcement of existing buildings, changes in cropping patterns as an adaptation to adverse environmental conditions, reforestation of river basins to diminish existing processes of erosion, landslides and flooding.

DANGEROUS PHENOMENON (EVENT): A natural, socio-natural (see definition below) or human-induced phenomenon that may cause damage to society. It's the materialization of a hazard in time and space. It's important to distinguish between a potential or latent phenomenon represented by the notion of hazard, and the phenomenon itself, once it occurs.

DISASTER: A social process triggered by a natural, socio-natural or human-induced phenomenon which, due to vulnerability conditions of human populations, infrastructure, and economic systems, causes intense, serious and extended alterations in the normal functioning of the affected country, region, zone, or community, to the extent that these are unable to respond autonomously and solve the problems with their own resources. The alterations may be diverse and differentiated, including loss of life, health problems among the general population, damage, loss or destruction of collective and individual goods, and damage to the environment. These alterations require the immediate response of both authorities and people, in order to attend the needs of the affected population and restore to acceptable levels their welfare and life chances.

DISASTER RISK: The probability that a certain level of adverse economic, social, or environmental consequences occur in a particular time and place, and that these are of such magnitude and severity that the community would be affected as a whole. This is derived from examining and factoring-in the hazards and vulnerabilities of exposed elements.

DISASTER RISK MANAGEMENT: A social process leading to the planning and application of policies, strategies, instruments, and more concrete intervention measures, in favor of the reduction, prevision and control of the possible adverse effects of a dangerous physical phenomenon on human populations, production systems, infrastructure, goods, services, and the environment. Comprehensive actions that favor risk reduction, prevision, and control, by means of prevention, mitigation, preparedness, rehabilitation, reconstruction, and recovery activities.

ECOSYSTEM: Spatial unit comprising a group of physical and biotic components and processes, which interact in an interdependent manner and have created characteristic energy flows, and material cycles or movements.

ENVIRONMENTAL DEGRADATION (DETERIORATION): Processes induced by human actions and activities which damage the natural resource base or which adversely affect natural processes and ecosystems, thus reducing their quality and productivity. Potential effects are numerous and include the transformation of resources into socio-natural hazards. Environmental deterioration can be the cause of a loss in the ecosystems' capacity to recuperate following external impacts. This loss of recovery capacity can, in turn, generate new socio-natural hazards.

EVERYDAY OR CHRONIC RISK: A series of living conditions which characterize (although not exclusively) poverty, under-development, and structural human insecurity, and which restrict or endanger sustainable human development. Examples of this can be found in poor health conditions, low life-expectancy, malnutrition, lack of employment and income, lack of access to potable water, social and family violence, drug addiction/substance abuse, alcoholism, and overcrowding of residential areas and individual housings.

EXPOSED ELEMENTS (ELEMENTS AT RISK): The social and material context represented by people, resources, infrastructure, production, goods, services, and ecosystems, which may be affected by physical phenomena due to their location in its area of influence.

HAZARD: A latent threat associated with the probable occurrence of a physical phenomenon of natural, socio-natural, or anthropogenic origin, which may be expected to have adverse effects on people, production, infrastructure, goods, services, and the environment. Hazards are risk factors that are external to the exposed social elements, and represent the probability that a phenomenon of certain intensity will occur at a specific location, and within a defined timeframe.

HAZARD ANALYSIS OR EVALUATION: The process by which the possible occurrence, magnitude, location, and temporality of a damaging physical event is ascertained.

NATURAL HAZARD: A latent threat associated with the possible occurrence of a physical phenomenon of natural origin; e.g., an earthquake, a volcanic eruption, a tsunami, or a hurricane. Natural hazards are normally classified according to their particular origin, which distinguishes between: geodynamic hazards (endogenous or tectonic, such as earthquakes and volcanic eruptions, or exogenous, such as landslides, avalanches, and subsidence); hydrological (such as slow- and rapid-onset floods, sedimentation, erosion, and desertification); atmospheric (storms and other meteorological and/or oceanographic phenomena, such as hurricanes and the El Niño phenomena); and biological (such as disease vectors, and agricultural pests).

PROSPECTIVE RISK MANAGEMENT: A process by which future risk is foreseen, and intervened or controlled. Prospective management should be seen as an integral component of development planning, and the planning cycle of new projects, whether these are promoted by governments, the private sector, or society. The final aim of this type of management is to prevent new risks, guarantee adequate levels of sustainability of investments, and avoid expensive, corrective management measures in the future. (See Risk Prevention, below.)

RESILIENCE: The capacity of a damaged ecosystem or community to absorb negative impacts, and recover from their effects.

RISK ANALYSIS: A projection of the probable social, economic, and environmental impacts of future physical phenomena on particular social and economic groups, areas or territories. This is achieved through an analysis of the hazards and vulnerabilities of exposed social and economic units. Changes in one or more of these parameters modify the levels of risk, the total expected losses, and the consequences for a given area.

RISK MANAGEMENT SYSTEM: An open, dynamic, and functional institutional and organizational structure created with the goal of promoting and facilitating the incorporation of risk management practices and processes to the cultural, social and economic development of the community, with full participation of society and its organizations. This should be accompanied by adequate orientation, norms, resources, programs, technical and scientific activities, and planning mechanisms.

RISK PREVENTION: Preventive measures and actions which seek to avoid future risks. This means working with probable future hazards and vulnerabilities. Seen from this perspective, risk prevention is a facet of prospective risk management, while risk mitigation or reduction relates to corrective management. Given that total prevention is rarely possible, prevention has a semi-utopian connotation, and should be seen in the light of considerations associated to certain socially acceptable risk levels.

RISK SCENARIOS: An analysis of the dimensions and types of risk that affect defined territories or social groups, and presented in written, mapped or other graphic forms, using quantitative and qualitative techniques and based on participatory methods. This implies a detailed analysis of hazards and vulnerabilities. Risk scenarios provide a basis for decision making on risk reduction, preparedness, and control. Recent developments of the notion of risk scenarios include a parallel understanding of causal social processes, as well as the social actors that contribute to existing risk conditions. A risk scenario is the result of an integrated risk analysis process.

SOCIAL PARTICIPATION: The process by which the subjects of development and risk take an active and decisive part in decision making, as well as in activities designed to improve their living conditions and reduce or prevent risk. Participation is the basis of the empowerment and development of social capital.

SOCIO-NATURAL HAZARD: A latent threat associated with the probable occurrence of physical phenomena, whose existence and intensity are related to processes of environmental deterioration, or human intervention in natural ecosystems. Examples can be found in the floods and landslides associated to deforestation and degradation or deterioration of watersheds; coastal erosion due to mangrove destruction; and urban flooding by lack of adequate drainage systems. Socio-natural hazards are generated at the interface between nature and human activities, and are the product of a process by which natural resources are converted into hazards. The new hazards associated with global climate change represent the most extreme example of socio-natural hazards.

SUSTAINABLE DEVELOPMENT: Environmental, economic, social, cultural, and institutional transformations that seek to provide long-lasting improvements in the quantity and quality of goods, services, and resources. The term also refers to social changes that promote the security and quality of human life, and improve its living conditions on an equitable basis, without deteriorating the natural environment or compromising the opportunities for similar levels of development for future generations.

VULNERABILITY: The propensity of humans and their livelihoods to suffer damage and losses when impacted by external physical phenomena. Differences in levels of human and livelihoods vulnerability may be explained by the incidence of diverse processes and conditions associated, though not exclusively, to the presence of insecure buildings and infrastructure; limited economic resources; low income levels; lack of social security; insecure livelihoods; poverty; inadequate educational, organizational and institutional arrangements; and a lack of well-developed social and political capital.

VULNERABILITY EVALUATION: The process which allows determining the susceptibility and predisposition to damage or loss by the possible occurrence of a dangerous physical phenomenon. This also includes an analysis of the factors and contexts which could impede substantially, or make more difficult, the subsequent recovery, rehabilitation, and reconstruction process of the affected social unit by its own means and resources.

WARNING (EARLY): A declaration emitted by any responsible and/or accountable institutions, organizations or individuals. Such warning implies adequate, precise, and effective information, which is provided prior to the occurrence of a dangerous phenomenon. This information should prompt emergency organizations to activate their previously established mechanisms, and get the people to undertake specific precautions. In addition to alerting people about the imminent danger, warnings are issued so all the local residents and relevant institutions may adopt specific actions when faced by a threatening situation.

GLOSSARY OF ACRONYMS

ABC: Brazilian Academy of Sciences
API: Application Programming Interface
BAPE: Barbados Association of Professional Engineers
BAPE: Barbados Association of Professional Engineers
CCCCC: Caribbean Community Centre for Climate Change
CCEO: Council of Caribbean Engineering Organizations
CERESIS: Regional Seismology Centre for Latin America
CFD: Computational Fluid Dynamics
CONACYT: National Council on Science and Technology, Mexico
CUBiC: Caribbean Uniform Building Code
ENSO: El Niño Southern Oscillation
GIS: Geographic Information Systems
HWSAI: Hurricane Wind Speed Adjustment Information
IADB: Inter-American Development Bank
IAI: Inter-American Institute for Global Change Research
ICSU: International Council for Science
ICSU - LAC: ICSU Regional Office for Latin America and the Caribbean
IDEA: Institute of Environmental Studies, Colombia
IDNDR: International Decade for Natural Disaster Reduction
IDNDR: International Decade for Natural Disaster Reduction
IPCC: Intergovernmental Panel on Climate Change
IPGH: The Pan American Institute for Geography and History
ISDR: International Strategy for Disaster Reduction
LA RED: Latin American Network for the Social Study of Disaster Prevention
LAC: Latin America and the Caribbean
NASA: National Aeronautics and Space Administration
NGO: Non-governmental Organization
OAS: Organization of American States
PAHO: Pan-American Health Organization
RCLAC: Regional Committee for Latin America and the Caribbean
UN: United Nations
UNAM: National Autonomous University of Mexico
UNDP: United Nations Development Program
USAID: United States Agency for International Development
UWI: University of the West Indies

ICSU
International Council for Science

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