ISDR

International Strategy for Disaster Reduction

Reducing Disaster Risks through Science

Issues and Actions

The Full Report of the ISDR Scientific and Technical Committee 2009

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Executive Summary

Disasters, disaster risk reduction, and the role of science

Increasing attention is being given to the rising impacts of disasters and to ways to reduce the exposure and vulnerability of communities and assets to natural hazards. In 2008, 321 disasters killed 235,816 people, affected 211 million others and cost a total of US$ 181 billion.[1] Economic losses from disasters in some countries have been greater than their national GDP. Losses with potentially catastrophic implications for the global economy include the possibility of a major earthquake in Tokyo (which seismologists assess could occur at any time within the next 150 years) with an estimated cost of US$ 1.2 trillion. However, although natural hazards will always occur, their impacts on society can be significantly reduced through the application of sound, evidence-based investments in disaster risk reduction.

Recognising the importance of scientific and technical information for disaster risk reduction, the UNISDR established a Scientific and Technical Committee to address policy matters of a scientific and technical nature, where science is considered in its widest sense to include the natural, environmental, social, economic, health and engineering sciences, and the term 'technical' includes relevant matters of technology, engineering practice and implementation.[2] The Committee decided at its second meeting on 30-31 October 2008 to prepare a short report for presentation at the Second Session of the Global Platform for Disaster Risk Reduction, in Geneva, 16-19 June 2009, in order to highlight the use of scientific and technical knowledge as an essential foundation for disaster risk reduction, and to make recommendations on key issues and priorities. This includes ways that specialist scientific and technical information can be more effectively adopted and put into practice. The present report is the result of that effort. This Executive Summary was tabled at the Global Platform as Session Document 3 and the key points were presented in the opening Plenary by the Chair of the Committee.

Practical applications of natural and social sciences to reduce vulnerability

Disasters are a concern for almost all countries and are growing in terms of people affected and economic losses. The number, scale and cost of disasters are increasing mainly as a consequence of growing populations, environmental degradation, unplanned settlements, expanding and ageing infrastructure, growing assets at risk, and more complex societies. By 2050 it is expected that the number of megacities in the world, many of which are located in exposed coastal zones or river plains, will have increased by a third. A changing climate will increase the risks for many regions. Risk and resilience are affected by the appropriateness of building design, urban planning and infrastructures for local circumstances.

Natural hazards strike hardest on the poor.[3] Disparities in vulnerability to natural hazards arise from wide gaps in access to resources and capacities for risk reduction associated with poverty and socio-cultural stratification. Addressing these factors and their damaging roles in development will require good foundations of social and economic knowledge and information, and the development of relevant scientific and technical capacities especially in developing countries. Related objectives to develop societal resilience are similarly dependent on sound scientific and technical knowledge.

The integration of science into policy development and implementation and practical problem solving can make major contributions to disaster risk reduction. Many examples exist—success stories but also failures—that reveal the importance of science and technology to disaster risk reduction.

For example, following a major cyclone in 1977 that resulted in about 20,000 deaths on the east coast of India, an early warning system was established, complete with meteorological radars and emergency plans. When the same area was hit by cyclones of similar strength in 1996 and 2005, the death tolls were just 100 and 27 respectively. On the opposite side of the world, operational real-time satellite remote sensing systems are being used to provide rapid assessments and potentially crucial information for disaster prevention for Fuego volcano, Guatemala.

Over many decades, seismology, engineering sciences and building administration have progressively developed design codes and standards to improve the earthquake resistance of buildings and infrastructures. Where these have been vigorously implemented in new buildings and through retro-fitting schemes for existing buildings, for example in earthquake prone Japan and California, USA, the loss of lives and damages due to earthquakes have been very significantly reduced. Accompanying risk assessments and public education programmes have contributed to high levels of awareness and preparedness of the population.

Throughout the world, millions of people living near rivers benefit very greatly from flood forecasting and evacuation systems and other risk management practices, and from the sustainable management of rivers and the use of flood plains. This is a major scientific and technical achievement that draws on the systematic integration of knowledge from meteorology, hydrology, agriculture, forestry, water and natural resources management, engineering and land-use planning.

Conversely, the Indian Ocean tsunami of 26 December 2004 provides a stark reminder of the catastrophic consequences that can ensue when scientific and technical findings are not transferred into policies and actions. Seismologists understood the seismic risks of the region and oceanographers had promoted the need for a tsunami warning system, but no integrated warning system had been implemented. Likewise, the hazard assessment recommending no building near Montserrat's Soufriere volcano was ignored, leading to over US$ 100 million of infrastructure damage during a subsequent eruption. In the United Kingdom, the severe damage and health problems that followed the 2007 floods revealed that warning communications were not sufficiently clear, timely or coordinated, and people, local government and support services were unprepared.

Selected topics - climate change, early warning, health and societal resilience

Rather than attempt to cover all of the dimensions of concern to disaster risk reduction— which cover diverse geographical and environmental settings, time frames, hazard types, different communities, sectors, and institutional issues—the Scientific and Technical Committee decided for this report to focus on four key selected topics, namely climate change, early warning systems, public health, and socio-economic resilience. These are topics of current policy concern for which immediate science-based actions are needed and possible. Other important topics, such as seismic risk prevention and reduction and the role of ecosystems in risk reduction and management, will be examined in future reports.

The basic facts of climate change are now well established, which itself represents an outstanding achievement for science and for policy-relevant international scientific cooperation. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)[4] projects increases in intensity or frequency for several types of extreme weather conditions, such as heat waves, droughts, storms, tropical cyclones and heavy rainfall, and their impacts will be compounded by other projected effects, such as sea level rise and reduced water supplies that will reduce the capacities of communities to cope with extreme events.

There is an urgent need to systematically link disaster risk reduction and climate change adaptation policies. This connection is recognised in the UNFCCC Bali Action Plan, which is guiding the preparations for a new agreement on climate change at the end of 2009 in Copenhagen. Another significant step is the decision by the IPCC to prepare an IPCC Special Report on "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation",[5] following a proposal jointly developed over 2008 and 2009 by UNISDR and Norway. This will provide a sound scientific basis for action to reduce the growing risks of disasters and to support UNFCCC policymaking and practical adaptation to climate change.

When properly implemented and adhered to, warning systems are a high-payoff activity to reduce disaster impacts and save lives, and for this reason, virtually all governments systematically invest in science-based early warning capacities, particularly through national weather services. Large populations are often evacuated from risk areas in response to timely warnings, for example in response to tropical cyclone alerts. Integrated all-hazard early warning systems that address time scales of minutes through to decades will be an important feature of climate change adaptation plans.

The natural sciences have generated a good understanding of the causes and behaviour of most natural hazards and together with the engineering sciences have enabled the development of effective surveillance and prediction systems. The health sciences have made similar achievements for health-related hazards and impacts. The social sciences have created a growing body of understanding of human resilience, the factors that influence people's attitude to risk and behaviour during a crisis, as well as the effectiveness of warning messages, channels for distributing messages, and mechanisms for eliciting public response.

There is a growing evidence base upon which we can improve our understanding of the health impacts associated with disasters, which are now recognised to extend well beyond the immediate crisis phase. What is now needed is continued support for multi-disciplinary research in this field coupled with efforts to translate knowledge into more effective policy and to bridge the gaps between environmental, humanitarian, development and governmental actors. Health sector responses to disasters need to be extended to take into account the whole breadth and longer timeframe of potential health impacts, including and beyond preparedness and recovery, in order to mitigate the total health, societal and economic burden of disasters.

Social and economic understanding is critical for building resilience and reducing disaster risks. Social science research provides significant insights into the conditions and processes that create inequity in exposure and vulnerability and that lead to the establishment of the unsafe conditions that characterize vulnerable communities. Such analysis can help us understand the complex factors involved, for example, in why people in some cities expose themselves to landslides by building houses in steep ravines, or settle on the slopes of still active volcanoes. Other key issues to consider are the nature of individual risk perception, the influence of institutional, social and economic conditions, and the limitations imposed by poverty, lack of experience, short-term goal focus and weak governance.

Achieving a more effective interplay of science, technology and policy

The Scientific and Technical Committee considers that much greater effort is needed to achieve more effective interplay of science, technology and policy in support of disaster risk reduction. This requires attention to three key areas: (i) better mechanisms for integrating science and technology into policy processes; (ii) greater interaction and collaboration among the scientific and technical disciplines including at international level; and (iii) systematic efforts to build relevant scientific and technical capacities.

In respect to the first of these, disaster risk reduction requires strategic planning and implementation as well as technical and scientific expertise. It sits at the interface of policymaking, engineering and scientific research, and requires a close and continuous exchange among these fields in order to provide effective and durable solutions.

Secondly, diverse expertise from different fields of science is needed in order to produce well suited solutions to risk-related problems. The science community has to learn to find better and faster ways to interact and to communicate substantial findings to policy makers and to support the development and implementation of solutions for emerging problems. This is not just a matter of developing trans-disciplinary processes among the natural sciences and engineering but also of fully incorporating the insights and methodology of social sciences and humanities into problem-solving approaches. Applied research, such as in the health and engineering sciences, provides a sound grounding in tried-and-tested best practice to practical solutions for prevention, preparedness and response. International collaboration is essential to maximise the benefits of science.

Thirdly, technical capacities for the provision of information and services may be unavailable or not adequately developed, constraining the prospects for sustainable development. There is an ongoing need for investment in research of both basic and applied types. The role and expertise of scientific institutions in developing countries are often not well recognised or supported, either within national priority setting or by international agencies. Yet it is these institutions, such as universities, geophysical, agricultural and health institutes and meteorological services that nurture and develop the essential bases of local knowledge for disaster risk reduction, and that can be the most effective advisers and communicators with leaders and local communities.

Recommendations

Following the considerations above, and as detailed more fully in the associated full report, the Scientific and Technical Committee makes the following recommendations.

(i) Promote knowledge into action

Greater priority should be put on sharing and disseminating scientific information and translating it into practical methods that can readily be integrated into policies, regulations and implementation plans concerning disaster risk reduction. Education on all levels, comprehensive knowledge management, and greater involvement of science in public awareness-raising and education campaigns should be strengthened. Specific innovations should be developed to facilitate the incorporation of science inputs in policymaking.

(ii) Use a problem-solving approach that integrates all hazards and disciplines

A holistic, all-hazards, risk-based, problem-solving approach should be used to address the multi-factoral nature of disaster risk and disaster risk reduction and to achieve improved solutions and better-optimised use of resources. This requires the collaboration of all stakeholders, including suitable representatives of governmental institutions, scientific and technical specialists and members of the communities at risk. Knowledge sharing and collaboration between disciplines and sectors should be made a central feature of the approach, in order to guide scientific research, to make knowledge available for faster implementation, to bridge the various gaps between risks, disciplines, and the stake-holders, and to support education and training, and information and media communication.

(iii) Support systematic science programmes

Systematic programmes of scientific research, observations and capacity building should be supported at national, regional and international levels to address current problems and emerging risks such as are identified in this report. The international Integrated Research on Disaster Risk (IRDR) Programme,[6] which is co-sponsored by ICSU, ISSC, and UNISDR, provides a new and important framework for global collaboration. The ISDR Scientific and Technical Committee should provide strategic guidance on research needs for disaster risk reduction and oversight of progress.

(iv) Guide good practice in scientific and technical aspects of disaster risk reduction

The ISDR Scientific and Technical Committee should be strengthened to serve as a neutral, credible international resource to support practitioners at all levels, from local through national to international levels, by overseeing the collection, vetting and publicising of information on good practices carried out on the basis of sound science and up-to-date scientific and technological knowledge, as well as on those inadequate practices or concepts that may be hindering progress. The Committee should further develop its recommendations for follow-up on the areas of concern highlighted in the present report, including on the themes of disaster risk reduction and climate change adaptation, preparedness and early warning systems, health impacts of disasters, and the association of disaster risk and socioeconomic factors.

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Section 1: Introduction

1.1 Disasters and disaster risk reduction

Increasing attention is being given to the growing problem of disasters and to identify ways to reduce the exposure and vulnerability of communities and assets to natural hazards. In 2008, 321 disasters killed 235,816 people, affected 211 million others and cost a total of US$ 181 billion.[1] Hazard events with potentially catastrophic implications for the global economy[7] include the possibility of a major earthquake in Tokyo (which seismologists assess could occur at any time within the next 150 years) costing US$ 1.2 trillion.[8] Losses from disasters are substantial and in some countries account for a major fraction of national GDP. For example, the 1999 earthquake in Turkey had an economic impact amounting to 8% of GDP and the hurricane in 1998 in Honduras amounted to over 75% of GDP. The economic impacts of disasters can have persistent and adverse long-term effects because they often destroy established patterns of livelihoods, production and trade. Climate change is set to have enormous impact on economic development and it will be the poorest countries and poorest people who will be most affected.

The UNISDR definition of disaster is "A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources."[9] It is important to distinguish between the natural hazard, which will always occur, and its impact on society, which arises from the exposure and vulnerability of communities and hence human decision and behaviour. While the hazards generally cannot be influenced, the magnitude and frequency of disasters can be significantly reduced through the application of sound, evidence-based investments in means to reduce the exposure and vulnerability components of risk. The Hyogo Framework for Action provides the internationally agreed framework of principles and priorities for action for achieving the desired reduction of disaster losses.[10]

The United Nations eight Millennium Development Goals have been established by the international community as the common framework for economic and social development activities of over 190 countries in ten regions, and they have been articulated into over 20 targets and over 60 indicators. In the 2008 report on progress on their achievement the role of disasters is acknowledged: "for the poor more than others, incomes are likely to be adversely affected by conflict, natural disasters and economic fluctuations."[11]

Disaster risk reduction faces many challenges. Major hazard events are usually rare for any particular community and in such situations the local citizen demand for investment in disaster mitigation and preparedness is often minimal. Since most of the burden for disaster recovery assistance is shouldered by central governments, local governments may have little economic or political incentive to invest in mitigation,[12] even though local governments are well equipped to play an instrumental role in hazard mitigation, owing to their close proximity to the hazards and the communities and because they control many of the most effective tools to achieve this objective (e.g., land use regulation, building code enforcement).[13] Conversely, in situations where frequent low-level damaging events occur, such as in poor communities, the national and local governments may not have the capacities or may be unwilling to address the root causes of the vulnerabilities that are present. In many cases the basic information and capacities required for disaster risk reduction, such as risk assessments, technical methodologies and trained experts and practitioners, may not be available. The Hyogo Framework expressly acknowledges the importance of political commitment, legal frameworks, institutional development, and budget allocations for disaster risk reduction.

1.2 Science role in disaster risk reduction

Scientific and technical matters were well recognised and addressed during the International Decade on Natural Disaster Reduction, 1991-2000 (IDNDR):

"Throughout the IDNDR and during the first year of the establishment of the ISDR, science and technology have been explicitly recognised as a key input in the strategy aimed at promoting successful risk reduction. ... The experience of the IDNDR shows that successful longer-term prevention strategies must be based on cross-sectoral and interdisciplinary co-operation involving the scientific community, national and local governments, NGOs, the private sector, as well as the organisations and agencies of the UN system."[14]

The IDNDR commenced with a largely technical and scientific focus and constituency, but gradually the need to include a wider socio-economic agenda and to involve political institutions was recognized. After the Yokohama conference in 1994, policy-makers and governmental institutions played an increasingly important role, and the issues of advocacy and political commitment became features of the International Strategy for Disaster Risk Reduction that was established in 2000 as the follow-up mechanism to the Decade. In recent years, however, there has been a concern that these shifts have been accompanied by a decline in the recognition of the role of science and technology.

Following the massive Indian Ocean tsunami of 26 December 2004, a Natural Hazard Working Group was established by the United Kingdom to investigate how science could help avoid such tragedies in future. Its report recommended the establishment of an International Science Panel for Natural Hazard Assessment to enable the scientific community to advise decision-takers authoritatively on potential natural hazards likely to have high global or regional impact.[15] Among other things it was recommended that this panel should be associated with the United Nations and should address gaps in knowledge, advise on potential future threats, and address how science and technology can be used to mitigate threats and reduce vulnerability.

Partly in response to this proposal, in 2008 a new ISDR Scientific and Technical Committee was formed, with the following principal terms of reference:[2]

"Recognizing that scientific information is the basis of informed decision making and public awareness, the main aims of the Committee are (i) to identify and address important questions of a scientific and technical nature; (ii) to provide scientific and technical advice to the Global Platform for Disaster Risk Reduction; and (iii) to assist in the coordination of scientific and technical activities within the ISDR system.

The Committee addresses policy matters of a scientific and technical nature, where science is considered in its widest sense to include the natural, environmental, social, economic, health and engineering sciences. The term 'technical' includes relevant matters of technology, engineering practice and implementation."

The Committee decided at its second meeting in October 2008 to prepare a short report on relevant matters for presentation at the Second Session of the Global Platform for Disaster Risk Reduction, in Geneva, 16-19 June 2009. The report aims to highlight the use of scientific and technical knowledge as an essential foundation for disaster risk reduction, and to provide recommendations on key issues, critical gaps and priorities for action. Among other things it addresses the ways that specialist scientific and technical information can be more effectively adopted and put into practice to support the reduction of disaster risks.

Section 2: Principal observations

2.1 Increasing number and likelihood of disasters

Disasters are a concern for almost all countries and are growing in terms of people affected and economic losses.[1] In 2007, a WHO survey found that nearly every country of the world had experienced a disaster during the previous five years.[16] Globalization, population growth,[17] widespread poverty, particularly in hazardous areas, and a changing climate will cause the risk associated with natural hazards to be even greater in the future, with more people and communities at risk.[1,3,18] The recent devastation caused by cyclone Nargis in Myanmar (138,366 deaths) and the earthquake in Sichuan, China (87,476 deaths) demonstrates the massive damage and loss of life that can occur from vulnerability to natural hazards.[19]

The basic scientific information upon which the projections of widespread and damaging impacts of climate change are based is now well established. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) 2007 Scientific Assessment,[4,20] projects that rising temperatures will lead to heat waves of unprecedented magnitude, particularly for cities, with potential for increased adverse health impacts. It is likely that future tropical cyclones (typhoons and hurricanes) will become more intense. Global sea level is expected to rise between 0.2 and 0.6 m by the end of the century, not including the rises that would accompany possible melting of major polar ice caps. More recent research increasingly indicates the possibility of greater sea level changes than projected by the IPCC. The likely impacts on ecosystems and human society, and for disaster risk, are significant. High sea levels and the increased intensities of tropical cyclones will lead to increased risk of coastal flooding and wave damage that will be a particular issue for populated deltas and low lying coastal cities. More extensive droughts and flooding are likely.

2.2 Increasing vulnerability

A number of factors accentuate the vulnerability of populations to natural hazards.[3] Population growth and increasing concentrations of people in unplanned cities and mega-cities, the limited choices of poor people resulting in their being concentrated in regions of high risk, such as along riverbanks and coastlines or on unstable slopes, are increasing the number of people at risk. By 2050 it is expected that the number of mega-cities in the world will have increased by a third.[17] The suitability of local building design, urban planning and infrastructures to the environment is important to local resilience. Planning decisions, for example, concerning agricultural development, new settlements or the concentration of transport infrastructures for greater efficiency, may potentially inadvertently increase the risks.

Natural disasters strike hardest for those with the least resources. Whereas in economically highly developed countries the average number of deaths per disaster is 23, the number increases dramatically to about 150 deaths per disasters in developing countries, and to over 1000 deaths per disaster in the least developed countries.[18] Underlying this disparity are wide gaps in access to resources for risk avoidance, risk reduction and response, arising from poverty and socio-cultural stratification. Disasters affect all countries but they are particularly damaging to developing countries in that they can also destroy or seriously impede development, while climate change can only worsen their impacts.

The context is now one of a fundamental change in the process by which communities are expected to prepare for and recover from disasters. Increasingly, resilience and the inclusion of mitigation measures must be integrated into the recovery process to enhance sustainable disaster recovery.[21] The recovery process must include a range of mitigation measures, and must leverage resources, local capacity-building, identification of local needs and a strong commitment from external agents to provide resources to meet local demands.

2.3 Successes and failures in the application of natural and social sciences to disaster risk reduction

The effective integration of science into policy development and practical problem-solving can make major contributions to disaster risk reduction, as is shown by the following examples.

In 1977, a major cyclone resulted in about 20,000 deaths on the east coast of India. In the years that followed, an early warning system was established, complete with meteorological radars and emergency plans, and many lives were saved as a result when the same area was hit again by cyclones of similar strength in 1996, when about 1000 deaths occurred, and in 2005, when the death toll was just 27.[22]

Over the past decade, remote sensing has been used increasingly in the study of active volcanoes and their associated hazards to adjacent settlements. Operational real-time satellite remote sensing systems now exist that can provide rapid assessments and potentially crucial information for disaster prevention, such as for Fuego, Guatemala.[23]

Earthquake science and engineering provides another excellent success story. Over many decades, seismology, engineering sciences and building administration have progressively developed design codes and standards to improve the earthquake resistance of buildings and infrastructures. Where these have been vigorously implemented in new buildings and through retro-fitting schemes for existing buildings, for example in earthquake-prone Japan and California, USA, the loss of lives and damage in earthquakes have been very significantly reduced. Accompanying risk assessments and public education programmes have contributed to high levels of awareness and preparedness of the population.[24] The early warning and preparedness systems put in place in the region of Kobe, Japan, after the devastating 1995 earthquake demonstrate the successful integration of multi-disciplinary science, policy-making and implementation. This included a sophisticated system of seismic sensors established through close collaboration between earth scientists, engineers and social scientists, and the participation of schools, both as a means of protecting pupils and as a way of educating families through their children.

Flood risk is another well-recognised area where science plays a central role, not only for forecasting flood events and evacuation needs, but also for providing a sound basis for the ongoing management of rivers and the use of flood plains. Millions of people benefit from the systematic integration of existing scientific knowledge from meteorology, hydrology, agriculture, forestry, water and natural resources management, and land-use planning. The sustainable development of river basins and the associated reductions in loss of life and destruction of assets are very visible outcomes of the capacities of modern science and engineering to serve both the public and private sectors.[25]

The following examples of failures, where science knowledge had limited impact on policy development and implementation, also provide important lessons.

The Indian Ocean tsunami of 26 December 2004 resulted in 305,276 dead or missing, over 500,000 injured and economic losses estimated at US$ 13.4 billion.[15] The lack of preparedness for such a tsunami disaster offers a stark reminder of the catastrophic consequences that can ensue when scientific and technical findings are not transferred into policies and actions. Seismologists understood the seismic risks of the region and oceanographers had promoted the need for a tsunami warning system, but no warning system had been implemented. In India, scientific advice to restrict the setting up and expansion of industries, operations and processes within 500 metres of the high-tide line had been incorporated into law in 1991 but had not been fully enforced.[26]

Other examples include the hazard assessment which recommended that no buildings should be present near Montserrat's Soufriere volcano but which was ignored, leading to over US$ 100 million of infrastructure damage during a subsequent eruption.[15,27] A European study documented examples where land-use guidance to control development in areas with a risk of flooding is complex and difficult.[28] In the United Kingdom, the severe damage and health problems that followed the 2007 floods demonstrated notable failings of the early warning systems, where warning communication was insufficiently clear, early or coordinated, and people, local government and support services were unprepared.[29]

It may be concluded that failures in problem-solving are often less due to shortcomings of scientific knowledge than to a lack of implementation that arises from not paying heed to advice and preparing in a timely manner, and an associated lack of trust and lack of understanding of how to convert scientific findings into applicable and efficient solutions. There is a great shortfall in current research on how science is used to shape and support social and political decision-making in the context of natural hazards and disasters.

From the successes, however, the evidence is clear that science with its various disciplines, coupled with education and policy implementation, have together substantially contributed to the reduction in loss of lives and loss of assets, and to building more resilient societies. Systematic integration across the sciences, and between the sciences and the social and policy fields, including education, is essential to achieve effective and durable outcomes. This includes the natural sciences that make the predictions possible; the social sciences that can provide necessary insights into the conditions that create such inequity in risk avoidance and recovery and the establishment of the unsafe conditions;[30,31] and the technical applications fields that make the system work and support the policy decisions that bring about practical implementations.

Section 3: Selected topics of current policy concern

Rather than attempt to cover all of the dimensions of concern to disaster risk reduction, which cover diverse geographical and environmental settings, time frames, hazard types, different communities, sectors, and institutional issues, the UNISDR Scientific and Technical Committee has decided for this report to focus on a selected set of four key topics, namely climate change, early warning systems, public health, and socio-economic resilience. These are topics of current policy concern for which immediate science-based actions are both needed and possible. Other important topics such as seismic risk prevention and reduction, and the role of ecosystems in risk reduction and management, will be dealt with in future reports.

3.1 Climate change

As touched on in section 2.1, the scientific foundations for the projections of widespread and damaging climate change are based are well-established, thanks to the processes of the Intergovernmental Panel on Climate Change (IPCC), and the issue is now recognised as a central and critical concern for global economic development and public safety. This represents an outstanding achievement for science and for policy-relevant international scientific cooperation.

Specific aspects of the IPCC scientific assessments that are relevant to disaster risks can be highlighted as follows. Scientific evidence and observation show that temperatures are rising and that this will likely lead to heat waves of unprecedented magnitude. Cities that currently experience heatwaves are expected to be further challenged by an increased number, intensity and duration of such events during the course of the century, with significant potential for additional adverse health impacts. Detailed observations and international collaborative assessments have been key elements in developing an understanding of issues of oceanic sea level and climate change and to establishing with high confidence that the ocean state has changed, sea levels are rising, and there is an increased risk of coastal flooding. Likewise, scientific modelling and analytical techniques show that future tropical cyclones (typhoons and hurricanes) are likely to become more intense, with larger peak wind speeds and heavier precipitation associated with the ongoing increases of tropical sea surface temperatures.

In addition to the changes in extreme weather events, such as heat waves, droughts, storms and heavy rainfall, there will be other longer term consequences of climate change, such as reduced agricultural production and reduced water supplies, that will weaken the capacities of communities to cope with extreme events, thus leading to further increases in losses and the risk of disasters.

The major intersecting issues are that disasters destroy or impede development and that climate change will increase their occurrence and their impacts.[32] For the poorest countries and communities, the consequences are likely to be especially devastating: the threat to lives, livelihoods, homes, and access to resources will contribute to trapping people and communities in a desperate cycle of poverty and ill health. Adaptation to climate change clearly will require the development of improved methods to manage hazards and reduce risks.[33]

There is therefore an urgent need to systematically link disaster risk reduction and climate change adaptation policies, and to coordinate strategies and actions on both issues at national, regional and global levels.[34] This connection was recognised in the Bali Action Plan,[35] in which the Parties to the UN Framework Convention on Climate Change (UNFCCC) set out their plan for reaching a new agreement on climate change at the end on 2009 in Copenhagen.

Moreover, the IPCC decided in April 2009 to prepare an IPCC Special Report on "Managing the Risks of Extreme Events and Disasters to

Advance Climate Change Adaptation",[36] following a proposal jointly developed over 2008 and 2009 by UNISDR and Norway. The aim of the Special Report is to provide a sounder scientific basis for action to reduce the growing risks of disasters and to support UNFCCC policymaking and practical adaptation to climate change. The report will provide an authoritative assessment of disaster risk reduction and management policies and practices, including their effectiveness and costs. Its preparation will involve hundreds of experts worldwide and will be completed by mid 2011.

It is also increasingly clear that disaster risk reduction and adaptation need to be integrated into strategies and policies for poverty reduction, economic growth and social development. A key message from the Stern Report[37] was that there is still time to avoid the worst impacts of climate change, if we act now and act internationally. While focused primarily on the urgent need for mitigation, the point applies equally well to adaptation and disaster risk reduction.

There are now many opportunities for the disaster reduction community to benefit from closer interaction with the climate change mitigation and adaptation communities and vice-versa. Mainstreaming climate change adaptation and disaster risk reduction together into national development processes clearly offers great benefits. All decision makers in all countries should be made aware of these issues and of the increase in disasters.[32]

3.2 Changing institutional and public behaviour to early warnings

Early warning systems rest on a sound basis of science. The natural sciences have generated a good understanding of the causes and behaviour of most natural hazards and coupled with the engineering sciences have enabled the development of effective surveillance and prediction systems. The health sciences have similarly developed systems for health-related hazards and impacts.

The social sciences have created a growing body of understanding of human resilience and the factors that influence people's behaviour during a crisis[38] and there is also substantial systematic social science research on the effectiveness of warning messages, channels for distributing messages, and mechanisms for eliciting public response.[38,39,40]

Disaster preparedness has an important influence on the damage patterns of extreme events, by reducing vulnerability and increasing resilience. To be prepared for the unexpected – on a local, regional or national level – needs constant adjustments in institutional and public behaviour. Early warning and preparedness systems must link and integrate the continuous monitoring of a hazard, the production of timely and accurate warning messages, and their effective communication to the populations at risk, which implies that people understand and engage with the messages.[41,42] When properly implemented and adhered to, these systems are a high-payoff activity to reduce disaster impacts and save lives, and for this reason, virtually all governments systematically invest in science-based early warning capacities, particularly through national weather services.

Large populations are often evacuated from risk areas in response to timely warnings, for example in response to tropical cyclone warnings or tsunami alerts. In 1977, a major cyclone resulted in about 20,000 deaths on the east coast of India. In the years that followed, an early warning system was established, complete with radars and emergency plans, and many lives were saved as a result when the same area was hit again by similar strength cyclones: in 1996 about 1000 deaths occurred while in 2005 the death toll was just 27.[22]

During the violent earthquake of May 2008 in Sichuan province, China, which resulted in about 90,000 deaths, the high awareness and preparedness in the Sangzao Middle School prevented casualties even though the school was situated near the epicentre. The school's director had been very conscious of the risks associated with seismic activity and had required students and teachers to take part in regular drills. When the earthquake struck, students and teachers evacuated according to well-rehearsed instructions. Some 1500 people gathered in the playground within 2.5 minutes. Nobody was injured. This illustrates the value of closely linking science-based knowledge with public awareness and practical preparedness action. Scientific methods to predict specific earthquakes are currently not available, so public warning systems are not possible. However, in Japan, anticipated ground accelerations across the country are estimated immediately after the occurrence of a large earthquake, allowing automated warning services to halt critical facilities such as electric trains within seconds before the wave of ground movement reaches them.

The early warning and preparedness systems in place in the region of Kobe, Japan provide an example of the successful integration of multi-disciplinary science, policy-making and implementation. After the Kobe earthquake of 1995, a sophisticated system of seismic sensors was put in place. A programme for close collaboration between earth scientists, engineers and social scientists was developed, and risk assessments and public education programmes were undertaken. The result is an early warning network which is further strengthened by high levels of awareness and preparedness of the population.[24] Schools are particularly involved in the system, both as a means of protecting pupils and as a way of educating families through their children.

Over the past decade, remote sensing has been used increasingly in the study of active volcanoes and their associated hazards. Now operational real-time satellite remote sensing systems can provide rapid assessment of volcanic activity levels and can potentially be used to derive crucial information for early warning and disaster prevention. It is likely that the use of satellite-based systems will be most beneficial for volcano monitoring in developing country regions and remote areas.[23]

Nevertheless, despite these successes, there is an overall concern that early warning systems have not been comprehensively implemented and that for some hazards and for many potentially affected communities there are no warning systems in place at all.[43] The Indian Ocean tsunami on 26 December 2004 tragically highlighted the situation, where the lack of technical warning systems and the lack of understanding on the part of the public about how to interpret environmental clues contributed to the hundreds of thousands of deaths and injuries.

Even where the science and technology is available and is being applied in warning systems, the warnings of particular events may not be effectively communicated, or adequately heeded or acted on, such as occurred during Hurricane Katrina. The failures during the 2007 British flooding, noted earlier,[29] are troubling after decades of technological and communication research on early warnings.

Analysing these problems highlights a number of key contributing factors, as follows.

Engaging the public, local institutions and support services

Knowledge of human and institutional behaviour must inform the design of early warning systems. Providing warnings and distributing information alone is insufficient to change public behaviour and create the level of alertness and response necessary to avert disaster. People must understand the information and be able to translate what it means in their own particular circumstances.[29] They must judge the warning to be credible and trust its source.[44] Furthermore, to a large extent people's response is a collective act, where they first discuss the meaning of a message with trusted others (family, friends or colleagues) before determining what action to take.[45] Effective communication engages its audience on the audience's own turf, in its language and taking local social networks into account—for example by holding public meetings in schools or local shops rather than in government buildings. An additional difficulty is that major hazard events are often relatively rare and their impact may seem far detached from everyday reality. Warnings and preparedness information must enable people to perceive the potential event as real. Examples of successful communication methods have included using film records and practical demonstrations. In the Netherlands, dolls houses were plunged in pails of water during public meetings to demonstrate the effect of flooding.[46]

An effective early warning policy should begin by identifying the at-risk population and organizations, including minority groups who may not respond to mainstream communication routes and public and private community support services. The target audience, whether it be the general public or institutions, needs to be involved in the design of preparedness plans if these are to suit local circumstances and be acted upon. A continuous process of engagement and re-engagement is required for people to retain a sufficient level of knowledge and alertness over time. This process allows policy makers and technical experts to hear and consider local knowledge, community structure and leadership, and cultural behavioural patterns in planning for risk reduction. It also fosters a greater sense of personal relevance and ownership of the plans by individuals, communities and institutions, thereby leading to better adherence and follow up. Addressing all these aspects should be part of the disaster risk reduction agenda.

Keeping pace with new communication technology

Most of the research on warnings was undertaken before the introduction of cable television, the internet, and mobile phones. These technological innovations offer new ways of reaching affected populations but they have also complicated the warning and risk communication process,[47] turning the issue from the linear model that officials could tightly control through the dissemination of messages through a small number of media, to a market-based arena of competing and conflicting messages that no single official can control or monopolize. The new communication patterns and technologies must be understood and harnessed, whilst retaining the trustworthiness of the source, to fashion the early warning systems of the future.

Increased cooperation between science and policy

The difficulties and examples discussed throughout this section highlight the importance of close collaboration between research, engineering and policy-making. Only when the three have been drawn together in the design and implementation of early warning systems have these been successful at provoking adequate responses and mitigating damage and casualties. The inclusion of the multiple disciplines of science in the design of warning systems is necessary to utilise the breadth of understanding of natural phenomena and human response which has now become available. Effective risk assessments should include the identification of all the populations and institutions that may become involved. For many natural hazards such as tropical cyclones and earthquakes, this also requires close regional cooperation. Scientists need to develop the capacity to explain the underlying complexity of early warning systems to policy makers. In turn, a strong and durable political commitment is required to support the implementation and updating of research findings.

3.3 Incorporating knowledge of the wide health impacts of disasters

Improving and protecting the world population's health and well-being is a prerequisite for achieving the Millennium Development Goals and the goals of the Hyogo Framework for Action. Natural hazards have greatest effect on the most vulnerable in the community: the poor, the children, the women and the elderly. There is a growing evidence base upon which we can improve our understanding of the health impacts associated with disasters.[48] What is now needed is continued support for multi-disciplinary research in this field coupled with efforts to translate knowledge into more effective policy and to bridge the gaps between environmental, humanitarian, development and governmental actors.

Medical emergencies and the health impacts of a disaster are important and highly visible aspects of the relief phase. The immediate impact in terms of fatalities and casualties is often at the forefront of media coverage. The difficulties in delivering medical care in the context of damaged infrastructures and the coordination of inter-regional or international collaboration tend to take precedence in the emergency response. However the health impacts of disasters can continue well beyond this immediate stage. Disasters may destroy local health infrastructures, thereby restricting the system's future ability to provide care and impacting on a much wider population than those directly affected by the original event. For example, the distribution of maternity care in the southern region of Sri Lanka had to be re-organised after damage to one maternity hospital by the tsunami of December 2004. Although the hospital sustained only minor damage, many women had to be referred to other maternity services across the country for almost three years after the event.[49] An increased risk of epidemics of infectious diseases has been observed after large disasters, particularly flooding, and in situations where people are sheltered in crowded structures with lack of adequate sanitation. Damaged infrastructures put affected populations at increased risk of accidents and increase their vulnerability to the environment, as well as exacerbating poor health and pre-existing disease. Over half the fatalities following the 1998 ice storm in Quebec, Canada were due to burns from improvised heating or lighting devices, carbon monoxide poisoning from the use of generators or propane stoves indoors and hypothermia.[50] Similar issues have been documented after most types of disaster.[51]

Additional long-term impacts may persist throughout and sometimes past the recovery phase. A study of the 1968 floods in Bristol, United Kingdom found that deaths and hospital admissions during the 12 months after the flood were double among those whose homes had been affected by the flood.[52] However, few studies have examined such long-term health consequences of disasters and research results are sometimes inconsistent between studies.[53] Psychological health effects are also among the most long-term outcomes of disasters.[54] Although most people who experience distress during a disaster recover rapidly, a sub-set of people will progress to post-traumatic stress disorder, depression or other psychiatric conditions. There is also evidence that suicides and child abuse rise following disasters.[55,56] The health consequences of disasters may even be passed from one generation onto the next, particularly if they affect such fundamental needs as access to food. Studies of the Dutch famine in 1944-45 found that very poor nutrition can affect foetal growth and lead to an increased risk of diabetes in the offspring, implicating a generational effect.[57,58]

Yet our understanding of the long-term impacts of disasters on health remains minimal. A number of factors make this type of research difficult and resource-intensive: the difficulties in following-up displaced populations for a long time, the inability to plan ahead for a pre-post disaster comparison, and other factors and events that may confound the results. A better understanding of the long-term consequences of disasters is crucial to more effective preparedness and response. It would help focus limited resources on the more likely and consequential health outcomes. Continued support for research and collation of experience is important and is likely to yield the most results if undertaken within the context of a multi-disciplinary investigation of the causes and consequences of disasters.

There also needs to be a greater understanding among policy-makers and the disaster risk reduction professionals that the health impacts of a disaster can be much more wide-ranging than the initial response suggests. Much expertise and skills have already been developed to support the emergency medical response to disaster events. Further effort to take into account the whole breadth and longer timeframe of potential health impacts would improve preparedness and recovery, and could contribute to mitigating the total health, societal and economic burden of disaster events. The health and scientific community clearly has a role to play in disseminating our growing knowledge of the broad health impacts of disasters.

3.4 Improving resilience to disasters through social and economic understanding

As already noted, those with the least capacities and resources are the most affected by natural hazards. Underlying this disparity are wide gaps due to poverty and socio-cultural stratification in access to resources for risk avoidance and response. Social science research provides significant insights into the conditions that create such inequity in exposure and vulnerability. The socio-economic processes that lead to the establishment of the unsafe conditions that characterize vulnerable communities include both recent and old social, economic and political factors, and may arise locally or from remote sources.[30] The analysis of such factors can help understand, for example, why people in cities of Andean countries expose themselves to landslides by building houses in steep ravines, and others throughout the world settle on the slopes of still-active volcanoes. Other key issues to consider in this context are how individual risk perception may be influenced by institutional, social and economic conditions, as well as the limitations which are imposed by poverty and lack of experience, weak governance and a setting dominated by short, rather than long-term, goals.[59] An important issue for planners and decision makers is to know the economic costs of ignoring risks and conversely of the various interventions needed to reduce risks.

Disaster risk assessments efforts involve the assessment of the natural hazards, the exposure of communities to the hazards and the vulnerability of the communities. The assessment of vulnerability, including the underlying factors that bring about such vulnerabilities and lead people to expose themselves to hazards, is a difficult and often neglected task that requires the specialist knowledge and skills of a range of social sciences.

Understanding vulnerability is all the more important in the context of a fundamental change in the process by which communities are now expected to recover from disasters. Traditionally, disaster recovery focused upon returning the impacted community to the pre-disaster status quo. Now, the focus is increasingly upon resilience and the inclusion of mitigation measures into the recovery process to enhance sustainable disaster recovery.[21] Important resources inherent in local resilience include economic resources, political empowerment, organizational capability, social capital, local knowledge and expertise, and community cohesion.[12] The recovery process must include a range of mitigation measures, and leverage resources, local capacity-building, identification of local needs and a strong commitment from external agents to provide resources to meet local demands.

The world's growing population and expanding urbanization greatly aggravate the risks of future disasters. Currently, half the world's population live in urban areas, and by 2050, the figure is expected to be about 70 percent; the urban areas of the world are expected to absorb virtually all the population growth over the next four decades, while at the same time drawing in some of the rural population.[17] Cities and towns in Asia and Africa are projected to register the biggest growth, resulting in 27 mega-cities with at least 10 million populations by the mid-century, compared with 19 today.[60] While planning and managing a mega-city may be an almost insurmountable challenge for many countries, the basic guidelines for reducing urban risks should be pursued by city governments as a priority. The Hyogo Framework of Action provides the principles involved in summary form.

A number of factors accentuate the vulnerability of cities to natural hazards. The concentration of a large population increases the scale of exposure to the hazards present. The suitability of local building design, urban planning and infrastructures to the environment will affect local resilience. Areas of impoverished and unplanned growth may be particularly vulnerable to flooding, storm damage and fire. Concentrated infrastructures pose potential risks of systemic failure to systems for transport, energy supply and communications.

New and improved strategies and methods are needed to address the variety of risks that face rapidly expanding urban areas. This includes the more intensive use of scientific information in planning and management, and the development of monitoring and early warning systems tailored to growing and emerging urban areas. Disaster-prone and economically developed countries usually already have such systems in place, as is the case in Japan where the probability of earthquakes hitting major urban centres in the next thirty years is closely studied and estimated[7,61] and the development and application of technologies for seismic resistant construction is accorded high importance. To reduce the impact of disasters worldwide, such strategies and resources need to be more effectively shared with developing regions as well.

Important contributions to preparedness and monitoring can be expected from the global use of geographic information systems (GIS). These can provide significant information about the likely resilience of a particular topography to hazards such as landslides, earthquakes and flooding, and are increasingly used by local authorities for the management of land uses and natural resources. They are most effective when combining remote methods, using satellite or aircraft-based imagery, and local knowledge and data, especially for urban conditions. There is increasing recognition that GIS applications and associated observational data sets must encompass developing regions of the world and new urban areas. The Global Earth Observation System of Systems (GEOSS) for example aims to coordinate global GIS space-based applications and share the knowledge with all nations.[62] The global development of earth observation methods will increase the capacity of science and engineering to inform policy, urban and rural planning, natural resource management and protection, and the enhancement of early warning systems.

Section 4: Achieving a more effective interplay of science, technology and policy

4.1 Better integration of science and technology into policy

Disaster risk reduction calls for strategic planning and implementation as well as technical and scientific expertise. It sits at the interface of policy-making, engineering and scientific research, and requires a close and continuous exchange among these in order to provide effective and durable solutions. The December 2004 Indian Ocean tsunami and Hurricane Katrina remind us of the catastrophic consequences that can ensue when scientific and technical findings are not transferred into policies and actions. Conversely, there are also many good examples of policy processes assimilating scientific knowledge, such as recent land-use legislation in Germany that requires planners to incorporate mitigation measures in flood plains.[63]

Enhanced integration of science, engineering and policy-making requires efforts on the part of all involved to facilitate the translation of technical expertise into socially acceptable and sustainable practical solutions. The challenge must be understood as bridging the gap between the wider scientific community and the sphere of policy-making. The scientific community has diverse realms, including the "hard" natural sciences, the "soft" social sciences and "applied" fields such as engineering and health. Within the sphere of policy-making, various organisations and perspectives coexist, including international, national and local governmental bodies and influential non-governmental organisations, with diverse responsibilities and areas of knowledge.

The disaster risk reduction agenda is closely tied in with population security concerns, with large economic, social and health burdens at stake. Improving our ability to mitigate the risks associated with natural hazards responds to basic societal needs for the security of persons and goods and well-being. Furthermore, as discussed previously, vulnerability to natural hazards correlates with levels of development, with a potential vicious circle in which those developing regions that are most vulnerable are often hit with the greatest impact. A better integration of scientific knowledge and adapted solutions to disaster mitigation strategies will therefore strengthen national and regional capacity to work towards the Millennium Development Goals. This will become increasingly important as our environment becomes modified and threatened by climate change.

A closer integration of science and technology into preparedness and recovery strategies will pay dividends. This will require political interest and commitment to reduce risk, and greater coordination among the relevant ministries, civil society and UN organizations and structures, particular among those concerned with long-term development, technical risk matters, and humanitarian response, and should build upon the achievements of the ISDR system.

A key requirement is to develop a greater understanding among decision-makers of the breadth of physical and social factors that influence disaster risk, population behaviour and the potential success of risk reduction policies. For example, the most technologically sophisticated early warning system will be ineffective if the local population is not adequately engaged in the preparedness process. Necessary understandings and commitment must be shared at all levels of government, international, national and local, if well-informed policies and legislation are to trickle down into sustained action on the ground and the implementation of best practice.

As one example, local planning authorities need to understand and trust the technically specific guidance on construction if buildings in flood plains and seismic areas are to be suitably designed. Scientific and technical information allows the production of robust risk assessments, and the private insurance sector is an important user of such information. However, too often risk data are not made use of or adequately incorporated into development planning, and where hazard maps do exist there can be gaps in their use to elaborate or update land-use norms and building codes.

A core challenge for the scientific community lies in becoming more successful at contributing its expertise outside its immediate world of science and technology. The style, language and complexity of scientific writings are well-recognised stumbling blocks for the implementation of scientific knowledge by a lay audience. To overcome this difficulty, the onus is largely on the scientific community to take steps to communicate results and guidance in the form of simplified, feasible, affordable and socially-acceptable solutions that respond to people's needs. The uptake of guidelines will remain low if users cannot understand the information or perceive its relevance to their own situation. There are many good examples of popularisation of scientific knowledge, such as joint efforts by the seismological community and civil engineers to produce understandable building codes. Further effort is required to adapt them to different social, economic and cultural contexts, however. With regard to earthquakes, for example, there is a need to adapt building guidance for use in lower-income settings, and particularly in the building of affordable private housing in developing countries.

The scientific community may also need to innovate and diversify the pathways it uses to communicate expert advice. The traditional publication of results in scientific journals is not designed to reach a wide audience. There needs to be further engagement of scientific and technical experts into policy-making bodies, so that strategic planning may directly benefit from the latest knowledge. This may require a shift in perception and priorities for scientists, and efforts to develop specialist intermediaries or interlocutors, with training and support to acquire new sets of communication and advocacy skills.

Public awareness-raising campaigns and education activities at both school and university levels offer important channels for communicating scientific and technical knowledge on disasters and their causes. This implies an increased familiarity with the various media and education methods, and working towards a greater understanding of what people want and need and what they are willing to adapt to. It can in return generate greater trust and engagement from the public in science-based systems and regulations. Similarly, the media can play a valuable role in providing the public with accessible and well-informed information about disasters and disaster risk reduction, especially at times of major disaster events.[64] The World Wide Web in particular is developing rapidly as an information and communication resource for the public.

4.2 Greater interaction among the scientific and technical disciplines

Effective routes to disaster risk reduction require diverse means and expertise, with the different fields of science joining forces to produce well-suited solutions to risk-related problems. This is not just a matter of developing trans-disciplinary processes among the natural sciences and engineering, but also of fully incorporating the insights and methodology of social sciences and humanities into problem-solving approaches. We can view natural science as the bellwether indicating the risk of specific hazards and the scope and direction of related technologies, and thus providing the prospects and hope for avoiding, minimizing or overcoming the risk. The social sciences provide the perspective and methods to understand human behaviour in response to risk and the use or rejection of technology, while the humanities provide means for engaging people in new narratives and images of better practice. Applied research fields, such as associated with the health and engineering sciences, add a sound grounding in tried-and-tested best practice to practical solutions for mitigation, preparedness and response.

Greater interplay between scientific disciplines can also help create the wider and longer view that is often the key to sustainable solutions. At times, for example, the solution to one hazard may help solve—or worsen—the problems of another. For example, during Cyclone Nargis in 2008, Myanmar benefited from the upgraded meteorological communications systems that had been installed for tsunami early warning purposes following the 2004 Indian Ocean tsunami. Countries such as Jamaica that suffer both from earthquakes and cyclones provide another example. In earthquake zones, houses should be designed with light roofs, so that damage is less likely under seismic shaking. However, in tropical cyclone regions, buildings with heavy roofs behave better in strong winds than those with light roofs. Here, advice from seismologists, meteorologists and engineers needs to be integrated in order to provide suitable compromise solutions.

Multidisciplinary collaboration will enhance all aspects of disaster risk reduction. A fully-informed hazard risk assessment, for example, must include a holistic analysis of the hazard, the risk and on-site vulnerability, requiring input from natural sciences, mathematical modelling, engineering, socio-economics, health sciences and others. Designing and updating early warning systems requires an understanding not only of the natural hazard, but also of local social conditions and population behaviour. Similarly diverse inputs are required to design and implement successful emergency plans and effective recovery programmes.

4.3 Promoting greater international collaboration

Natural hazards and associated disasters do not respect political boundaries. They often have direct or indirect impacts on several different countries at the same time, calling for international collaboration for preparedness, response and recovery. In this context, international cooperation on natural hazard monitoring and characterization, common data and alert systems and capacity development is important. It can engender more effective solutions, reduce duplication and promote the transfer of resources and know-how across political and economic boundaries. It is particularly necessary for early warning systems, such as those for weather hazards coordinated by the World Meteorological Organization and for tsunami hazards coordinated by UNESCO's Intergovernmental Oceanographic Commission.

Natural hazards remain inadequately studied in many regions, particularly in the developing world where lack of capacity and resources hinder local efforts. Many countries, for example, do not have adequate ground-based observations systems to be able to study, predict and anticipate the hazards they are exposed to. Lack of baseline information is particularly of concern where departure from baseline behaviour is the means to signal the onset of an event (e.g. a volcanic eruption). For example, the explosive histories of just one-fifth of all volcanoes in the world are documented, and very few outside the developed world are systematically monitored. Mount Cameroon, for example, Africa's largest volcano, has no seismic network. Intra-regional and global data gathering and scientific cooperation is therefore a basic priority for disaster risk research and preparedness. International scientific networks can also serve as the conduit for the transfer and adaptation of knowledge and technology from rich to moderate-income and lower-income countries.

International scientific networks can also facilitate the transfer of experience and lessons learned between different regions that are exposed to similar hazards. Sharing experience in this way can be particularly valuable in the case of very rare events. Stable continental earthquakes, such as those which occurred in New Madrid, USA in 1811-1812, provide a good example. They are unlikely to re-occur in the same area for several hundreds of years, but may occur in other parts of the world. Rather than lose the knowledge gained after the event, lessons learned should be shared with other susceptible regions.

In response to the challenges described above, a new international, multidisciplinary programme "Integrated Research on Disaster Risk: addressing the challenge of natural and human-induced environmental hazards"[6] has been established by the International Council for Science (ICSU) with the co-sponsorship of the International Social Science Council (ISSC) and the UNISDR. This will build upon, complement and extend existing scientific research programmes to provide the capacity at all levels and in all geographical contexts for addressing hazards and making informed decisions on actions to reduce their impacts. The programme will facilitate collaboration between global partners in research, including: the World Climate Research Programme; the World Weather Research Programme; the International Human Dimensions Programme on Global Environmental Change and its Integrated Risk Governance Project;[65] intra-regional and global scientific networks and global capacity building programmes similar to START (the global change SysTem for Analysis, Research and Training);[66] and programmes for globally integrated observation systems, especially those seeking to improve coverage of the developing world, such as through the work of the Group on Earth Observations.[62] Given the evidence of increasing disaster risk, and the growing demand for sound methods to deal with and reduce disaster risk, these programmes and their coordination will become increasingly important foundations for informed cost-effective action in the future.

4.4 Capacity development

Many regions of the world still lag far behind in terms of provision of information and services required for disaster risk reduction, and as a result their prospects for sustainable development will remain constrained. Most critical is the lack of capacity in terms of human, institutional and material resources for a range of disaster reduction needs, including identifying hazards, exposure levels and vulnerabilities and thereby characterizing risk, as well as integrating this information into national and regional development goals, informing the public, and developing risk reduction programmes. The expertise and potential roles of scientific institutions in developing countries are often not well recognised or supported, either within national priority setting or by international agencies, yet it is these institutions, such as universities, geophysical, agricultural and health institutes, and meteorological services, that nurture and develop the essential bases of local knowledge for disaster risk reduction and that are, or can be, the most effective advisors and communicators with the local communities.

With the global increase in the number of disaster events and the threat of growing climate change impacts, there is an urgent need for a careful assessment and mapping of the existing capacities for all aspects of disaster risk reduction. This would determine the strengths and weaknesses in respect to different hazards in different geographic locations and social systems, and the different scientific, technical and operational capacities. It would also facilitate learning from past and ongoing capacity-building efforts and how these have been linked to national development agendas, regional collaborations and international programmes for disasters. The abovementioned START network is an example of human and institutional capacity development that is focused on developing local human capacities in scientific and technical fields to support sustainable development in developing countries, and could provide an appropriate model for building related capacities in disaster risk reduction.

Section 5: Recommendations

Following the considerations above, the Scientific and Technical Committee makes the following recommendations. Relevant parties, particularly within the scientific and technical fields, are encouraged to translate these into concrete actions within their areas of mandate.

(i) Promote knowledge into action

Greater priority should be put on sharing and disseminating scientific information and translating it into practical methods that can readily be integrated into policies, regulations and implementation plans concerning disaster risk reduction. Education on all levels, comprehensive knowledge management, and greater involvement of science in public awareness-raising and education campaigns should be strengthened. Specific innovations should be developed to facilitate the incorporation of science inputs in policymaking.

(ii) Use a problem-solving approach that integrates all hazards and disciplines

An holistic, all-hazards, risk-based, problem-solving approach should be used to address the multi-factoral nature of disaster risk and disaster risk reduction and to achieve improved solutions and better-optimised use of resources. This requires the collaboration of all stakeholders, including suitable representatives of governmental institutions, scientific and technical specialists and members of the communities at risk. Knowledge sharing and collaboration between disciplines and sectors should be made a central feature of the approach, in order to guide scientific research, to make knowledge available for faster implementation, to bridge the various gaps between risks, disciplines, and stakeholders, and to support education and training and information dissemination and media communication.

(iii) Support systematic science programmes

Systematic programmes of scientific research, observations and capacity building should be supported at national, regional and international levels to address current problems and emerging risks such as are identified in this report. The international Integrated Research on Disaster Risk (IRDR) Programme,[6] which is co-sponsored by ICSU, ISSC, and UNISDR, provides a new and important framework for global collaboration. The ISDR Scientific and Technical Committee should provide strategic guidance on research needs for disaster risk reduction and oversight of progress.

(iv) Guide good practice in scientific and technical aspects of disaster risk reduction

The ISDR Scientific and Technical Committee should be strengthened to serve as a neutral, credible international resource to support practitioners at all levels, from local through national to international levels, by overseeing the collection, vetting and publicising of information on good practices carried out on the basis of sound science and up-to-date scientific and technological knowledge, as well as on those inadequate practices or concepts that may be hindering progress. The Committee should further develop its recommendations for follow-up on the areas of concern highlighted in the present report, including on the themes of disaster risk reduction and climate change adaptation, preparedness and early warning systems, health impacts of disasters, and the association of disaster risk and socioeconomic factors.

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