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Foresight

Reducing Risks of Future Disasters

Priorities for Decision Makers

Executive Summary

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Foreword

Today, there are more people at risk than ever from natural hazards, particularly in developing countries, and this number will continue to rise over the next 30 years. Indeed, disasters arising from tsunamis, earthquakes and epidemics, as well as extreme weather events, seem to be often in the news. Clearly, the emergency response of aid organisations and governments is vital in such circumstances. However, it is important to ask whether more could be done to anticipate such events, to limit their impact, and to enable the affected populations to recover more quickly through better resilience.

The issue of disaster risk reduction (DRR) was a central question of the Humanitarian Emergency Response Review chaired by Lord Ashdown and which reported in 2011. However, choosing to deploy resources for DRR is not a straightforward decision for policy makers with limited resources. There can be real difficulties in justifying expenditure to address hazards that might not occur for a very long time, or indeed may never materialise. And if precious resources are to be used for DRR, there will be important decisions concerning where the greatest benefits might be achieved.

The good news is that science has the potential to play an increasingly important role in DRR. Science tells us why disasters happen and where many of the risks lie, and for some disasters we can even forecast when they will occur. The aim of this Report has therefore been to review the latest science and evidence, and to take stock of the further improvements that lie ahead. In so doing, it sets out priorities and options for how DRR can be substantially improved today and into the future. The key message is that disaster and death are not the inevitable consequence of greater exposure to hazards. It is possible to stabilise disaster impacts, save lives and protect livelihoods. However, achieving this will require a change in culture and a new approach. Everyone with a stake in developing countries needs to play their part in reducing risk. For example, this Report argues that policy makers far beyond the traditional boundaries of development and disaster response need to recognise that they also have a key part to play in DRR, as does the private sector.

This Report has drawn heavily on the considerable amount of excellent work that is already taking place on DRR across the world. Also, I am particularly grateful for the team of leading experts, chaired by Professor Angela McLean, who have led this work, and to the many others who have contributed to this Project. In conclusion, I hope that policy makers, and indeed everyone involved in addressing the challenge of disasters, finds this Report useful.

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Executive summary

1 The aims and ambitions of the Project

This Foresight Project has considered disasters resulting from natural hazards. The aim has been to provide an independent look at the latest science and evidence, and its role in disaster risk reduction (DRR), so that the diverse impacts of future disasters can be effectively reduced, both around the time of the events and in the longer term.

The work looks out to 2040 and takes a broad and independent view. It investigates how science and evidence could help in understanding evolving future disaster risks, how those risks may better anticipated and the practical actions that could be taken in risk reduction. Throughout, it has drawn upon the latest developments in natural and social science, and lessons from the many existing DRR initiatives. It is supported by 18 independently peer-reviewed papers, which were specially commissioned from leading experts across the world[1], as well as workshops and an international summit of senior policy makers that took place in June 2012[2].

2 Why the Project was commissioned

Important drivers of change could substantially increase future risks of disasters, notably the increasing frequency of extreme weather events due to climate change, and large population increases in cities exposed to natural hazards. However, choosing to deploy resources to reduce these risks presents significant challenges for policy makers. There can be real difficulties in justifying expenditure to address hazards that may occur infrequently, or indeed may never materialise in a given location. In responding to those challenges, it makes clear sense to make full use of new developments in science and evidence.

The need to improve disaster risk reduction, and the many difficulties inherent in achieving that aim, is also a recurrent theme in a number of recent reviews. These include the Humanitarian and Emergency Response Review (HERR[3]) led by Lord Ashdown, which formed the catalyst for undertaking this Foresight Project[4], and reports on managing disaster risk and preventing disasters from the Intergovernmental Panel on Climate Change (IPCC) (2012)[5], and the World Bank and United Nations (2010)[6]. Arguably, these reviews imply a growing political interest in improving current efforts to reduce disaster risk. Impacts from disasters were also cited in five imperatives for decision making by the UN Secretary General at the 2011 General Assembly's annual high-level debate, and the integral role of disaster risk management in development policy was highlighted at the 2012 G20 Summit in Mexico.

1 See Annex B of the Final Project Report for a list of references, and Annex C for a list of reviews commissioned.
2 See Annex A of the Final Project Report for a list of the many individuals from academia, industry, as well as governmental, non-governmental and international organisations who have been involved in this Foresight Project.
3 Ashdown, P. (2011) – see Annex B for a list of references cited in this Foresight report.
4 In addition to the Foresight Project reported here, a separate study has been undertaken within the UK Government Office for Science to advise how scientific advice relating to disasters can be better incorporated within decision processes specifically within the UK. Further details of that project (The Use of Science Advice in Humanitarian Emergencies and Disasters) can be found at http://www.bis.gov.uk/go-science/science-in-government/global-issues/civil-contingencies/shed-report-2012.
5 IPCC (2012).
6 World Bank and United Nations (2010).

3 Assessing disaster impacts: lessons from the past and present

A review of past and present disasters shows that impacts can be extremely diverse in nature, operating over widely different spatial scales and developing over very different timescales. In the 20 years to 2012, disasters killed 1.3 million people and caused US$2 trillion of damage, more than the total development aid given over the same period[7]. Droughts, earthquakes and storms have been the largest causes of disaster mortality in the last 40 years.

Indirect impacts may be less visible, but have the potential to blight lives over the long term. The key message is that the combined consequences of direct and indirect impacts are both poorly understood and poorly documented and therefore likely to be underestimated.

Examples of indirect impacts of disasters include:

- Economic contagion effects through globalisation: disasters have a significant impact on world trade flows. It has been estimated that major disasters reduced world trade by 1-4% over the 40-year period ending in 2003 and that the trend was for increasing proportional losses despite a parallel expansion in world trade[8].
- Household consequences: the prospect of future losses can reduce the incentive to save and invest, and repeated losses can prevent households moving out of poverty. Loss of assets such as livestock can have long-lasting negative effects.
- Malnutrition in children: specific types of malnutrition at critical times in a child's development can lead to long-term effects such as stunting.

4 Drivers of future disaster risk

A critical element of reducing disaster impacts in the future is the application of science and evidence to assess disaster risk, in order to anticipate and prepare for future hazards. In this Report, the main determinants of disaster risk are taken to be the magnitude of the hazard, exposure and vulnerability. These determinants, and hence disaster risk, will be influenced in the future by a wide range of drivers.

Two drivers stand out in this analysis because of their potentially large and negative effects on disaster risk, and the low associated uncertainty: global environmental change and demographic change. Global environmental change and demographic shifts are likely to continue over the next three decades, leading to greater hazard exposure and vulnerability, as well as reduced resilience and increased uncertainties. The speed of urbanisation in developing countries is also an important driver of change: urban design and planning that both improves the quality of life for residents and makes expanding cities resilient to natural hazards is therefore a key priority.

Changes in climate due to global warming are widely expected in the coming decades. Rising temperatures will affect weather and precipitation patterns, sea levels may rise and the average maximum wind speed of tropical cyclones is likely to increase. The expected increase in frequency of climate extremes[9] will, in turn, increase hazard exposure and the risk of events such as droughts, flooding and storm surges affecting different regions in different ways. Although changes over the next three decades may only be small, the long-term trend towards more extreme events is important.

7 UN International Strategy for Disaster Reduction (2012a).
8 Gassebner, M. et al (2006).
9 IPCC (2012), pp11–16.

Much of the demographic change over the next three decades is already locked in to existing population distributions. By 2040, the population of 'least developed' countries will have risen to around 1.5 billion[10]. Many of these countries have a high proportion of their populations at risk from one or more natural hazards[11]. For example, populations living in urban floodplains in Asia may increase from 30 million to between 83 and 91 million in 2030[12]. Between 2010 and 2040, the number of people over 65 in less developed countries is projected to nearly triple, from 325 million in 2010, to 948 million in 2040[13]. In emergencies, older people face particular risks and are a vulnerable group, although they may have skills and experience which enable them to cope[14].

A third driver is urbanisation. Already, eight out of the ten most populous cities in the world are at risk of being severely affected by an earthquake, and six out of ten are vulnerable to storm surge and tsunami waves[15]. The number of urban dwellers in developing countries is projected to increase linearly by 65 million each year from 2.6 billion in 2010 to around 4.7 billion in 2040. Currently, around 30% of the population of many urban centres in low- and middle-income countries live in informal settlements or in overcrowded and deteriorating tenements. In many African and Asian cities, the proportion is 50% or more[16]. Large concentrations of these informal settlements are located on land that is at high risk from flooding or landslides[17]. However, there are reasons to believe that well-managed cities can limit vulnerability and mitigate hazards given appropriate information and governance systems. But many cities are still not addressing their rapidly increasing risk.

The net effect of these and other drivers is complex and unpredictable. Many will interact, adding to the uncertainty. Much will depend on the degree to which governments and other decision makers take effective action to manage the effects of these drivers and reduce disaster risk. Some countries have made good progress in reducing disaster impacts for particular hazards (for example, Bangladesh and Chile in cyclone and earthquake impacts respectively). Nevertheless, the two drivers with the most certain future trends, demography and environmental change, are also likely to increase disaster risk significantly.

- The speed of urbanisation in developing countries means that the future vulnerability and exposure of cities will be disproportionately important. Urban design and planning that both improves the quality of life for residents and makes expanding cities resilient to natural hazards is therefore a key priority.
- Trends such as urbanisation, economic development and technological change present opportunities to reduce exposure and vulnerability, and strengthen resilience, if they are exploited effectively.

Some particular hazards have the potential to result in especially serious impacts in the future, for example:

- Earthquakes in megacities pose a major threat, as does flooding for the many cities in low elevation coastal areas: 192 million more people will be living in urban coastal floodplains in Africa and Asia by 2060. Preparing for earthquakes will be challenging as both their timing and severity are very difficult to forecast.
- The average maximum wind speed of cyclones in many developing countries is very likely to increase, along with the number of people living in at risk areas, particularly after 2040.
- Dense, urban populations are at particularly high risk of emerging infectious diseases.

10 Population Reference Bureau (2012).
11 Dilley, M. et al (2005).
12 Foresight (2011).
13 United Nations Department of Economic and Social Affairs (2011).
14 HelpAge International and United Nations Population Fund (2012).
15 Chafe, Z. (2007).
16 International Institute for Environment and Development (2012).
17 Hardoy, J.E. et al (2001).

5 Forecasting disaster risk: future science

Science already explains why disasters happen, where many of the risks lie and, for some disasters, forecasts can be made of when they will occur. In the next few decades, scientific advances in the understanding of natural hazards can be expected to continue. Progress in data analysis and advances in technology will play a role in this process. How fast and how far such improvements will proceed is uncertain. But if progress continues at the current rate, there will be increasingly reliable forecasts identifying the timing and location of some future natural hazards. At the same time, more detailed descriptions of the locations of people and assets, and of coping abilities that will allow better assessments of exposure and vulnerability will become available. Together progress in these areas will improve the forecasting of disaster risk and provide opportunities for effective disaster risk reduction, provided that those who need to take action have ready access to the information.

Forecasting hazards

Improving the scientific understanding of hazards is crucial to better risk forecasting[18]. Scientific advances in DRR have already helped to save many lives. For example, improved forecasts of tropical cyclones have led to reductions in fatalities, and early warning systems have reduced flood damage. The current state of hazard forecasting is variable across types of hazard and across the world.

The emergence of probabilistic forecasts has changed the way in which forecasts of natural hazards are made and understood. Determining whether or not a forecasting system is reliable requires a large sample of forecasts but this is impeded by the rarity of disasters. Although this unreliability will be reduced over the next few decades through scientific advances, probabilistic forecasts will continue to be imperfect. The current state of hazard forecasting is variable, but in the case of some hazards, for example cyclones, forecasting skill is rapidly improving. The best forecasts in the future will be reliable, probabilistic forecasts. However, gaps in forecasting ability will remain, notably in predicting the timing and magnitude of earthquakes and disease outbreaks.

The specific findings are as follows:

- Improved forecasting of hydrometeorological hazards requires more robust observation systems for the atmosphere, oceans, cryosphere and land surface. Higher resolution models that have the potential to increase forecasting power in parts of the world where it is currently low, can be expected in the next 20 years[19]. They will require computers in the exaflop range, which may be developed in another decade or so.
- Recent progress and future potential indicates that the ability to forecast floods should improve significantly over the next 10 to 20 years through the development of satellite technology (e.g. the capacity to determine river flow in real time), better modelling, and an improved understanding of the interaction of hydrological and meteorological processes.
- Forecasting of droughts is still in its infancy but some improvements can be expected over the next 20 years, driven by the launch of the next generation polar satellites in 2016[20] and improvements in the coverage and quality of observation stations. Access to high resolution satellite data within the next five years will drive progress over the next 20 years.
- The ability to forecast the timing of earthquakes remains a distant possibility, and whether it will ever be realised is uncertain. The lack of data and great heterogeneity of geological systems means that it is unlikely that earthquakes will be forecast with sufficient confidence to provide reliable warnings within the next 30 years. The study of slow earthquakes and the modelling of complex seismic cycles offer potential routes

18 In this Report, the term 'forecast' is used to describe in a simple way all attempts to make statements about future risk, whether concerning a particular expected hazard or an average expected risk over time.
19 Dutra, E. et al (2012a).
20 Patel, R. (2012).

forward. Higher resolution and increased coverage of earth observation (e.g. interferometric satellites), and seabed ground motion monitoring will be required. Forensic data on past events will also be important.

- Successful forecasts of volcanic eruptions have been achieved where volcanoes have been monitored (e.g. in Montserrat since the 1995 eruption). Over the next 10 to 20 years, forecasting will continue to improve through better monitoring and analysis of datasets derived from higher resolution and increased coverage of earth observation (e.g. interferometric and gas monitoring satellites), and forensic data on past events.
- Forecasting when tsunamis will occur is difficult regardless of whether they are triggered by earthquakes, volcanoes, submarine landslides or a combination of hazards. Yet, once triggered, the time of landfall of the deep-water wave can be forecast. Progress in modelling the nonlinear interactions between the wave and the seabed[21] might lead to improved operational forecasts of inundation through, for example, high resolution (multibeam) seabed geomorphic mapping, seabed ground motion monitoring, and forensic data on past events over the next 10 to 20 years.
- In humans and livestock, predicting the future spread of infection will remain difficult because it requires a profound understanding of the pathogen's interactions. But there are reasons to be optimistic. It may be possible in the next few decades to forecast when a novel, directly transmitted infection, similar to, for example, the SARS virus, will reach different parts of the world from studying aviation patterns. Highly resolved descriptions of the mixing patterns of hosts and a deeper understanding of host-pathogen interactions will be developed over the next ten years.
- Changing diets in developing countries are driving increased stock densities, mostly in pig and poultry production (e.g. from 1992 to 2002 Asian poultry production increased by 150%) creating large animal populations which are susceptible to infection. Similarly, about 40% of global agricultural land is covered by wheat, maize and rice varieties which have high levels of genetic uniformity. Across all classes of pathogen (including those that are well-known, recently emerged in a new host species, and not yet emerged) forecasting the location, severity and timing of disease outbreaks in livestock and in plants is much less developed than is the science for outbreaks in humans.

Increased co-operation and pooling of resources for hazard prediction is likely to be beneficial in specific areas. Consideration of the technical, organisational and commercial barriers to achieving greater co-operation in hazard prediction would be helpful.

Pooling resources may be advantageous where:

- the physical processes underpinning hazards are similar across much of the world (one example would be global circulation models for hydrometerological hazards where a single forecast would be of use to many);
- infrastructure for data (e.g. satellites and sensors) and for modelling (e.g. supercomputers) is expensive.

However, it will be important to achieve a balance between pooled resources (which can save costs) and individual facilities (which can help to foster diversity of approach and innovation in hazard prediction).

Forecasting vulnerability and exposure

The scientific advances in anticipating natural hazards discussed above can only be exploited for disaster risk forecasting if exposure and vulnerability of people and assets are also assessed. These are crucial components in forming accurate disaster risk projections. However, they are hard to measure because they depend on local circumstances and priorities. The quality and coverage of data on vulnerability and exposure are also generally very poor in developing countries. Developing methods of measurement that take into account local context and priorities would improve the situation.

21 Schlurmann, T. et al (2010).

Exposure[22] encompasses the spatial and temporal distribution of populations and assets. There is a general concern about the quality, coverage and time span of census data and those most at risk of exposure are often in developing countries with highly dynamic populations and the least reliable information. Remotely sensed images of dwellings are increasingly used to support or supplement census data[23 24].

Measuring vulnerability[25] is much more difficult. It resists global characterisation because it is influenced by contextual factors and is therefore sensitive to diverse social and cultural values. Many vulnerability assessments undertaken in low-income, at-risk communities are focused on raising risk awareness and developing organisational capacity, and only a few local studies and assessments have used systematic techniques for recording, generating and analysing data. But the scientific literature on vulnerability, while scarce, is growing rapidly. More refined risk forecasts can be made by including metrics for vulnerability which reflect locally relevant measures of deprivation and the impact of local governance capacity.

Looking across all aspects of risk forecasting (hazard, exposure and vulnerability) there are options for better co-ordination between communities of experts at several levels.

These include:

- **Co-ordination on data issues:** a good example is the Group on Earth Observations. This has successfully brought together 64 international agencies to build a Global Earth Observation System of Systems. However, the terms of its 'International Charter' do not allow data to be made available for disaster risk reduction.
- **Co-ordination on single hazard forecasts:** computers in the exaflop range (10^{18} floating point operations per second) will be needed to produce ensemble forecasts of single hazards using high-resolution models, which will provide much more reliable and locally relevant forecasts. Providing this capability is expensive and international pooling of resources and expertise may offer one way of achieving this.
- **Co-ordination on multiple hazards:** the development of a systems-based approach to geophysical hazard analysis, specifically where primary hazards (such as earthquakes) can trigger secondary hazards (such as tsunamis) would be an example. Historically, most risk analysis has been undertaken on a hazard-by-hazard basis. In particular, integrated modelling of multiple, inter-related hazards will require the integration of data and models from multiple sources.
- **Better co-ordination between those working on hazards, exposure and vulnerability could achieve substantial improvements in risk modelling and evaluation:** for example, Africa Risk View[26] aims to combine rainfall forecasts with agricultural models to forecast where crops will suffer water stress. This information is combined with local data on vulnerability to determine how many households would be affected economically or would experience hunger. Where collaboration between areas is limited, interoperability of outputs such as data and models will be important in promoting interdisciplinary working.

Looking to the future of modelling disaster risk there is potential over the next two decades for highly co-ordinated activity to address the computationally intensive modelling of physical processes and natural hazards which are globally distributed. Modelling would produce standardised outputs, which could be combined with local information on exposure and vulnerability to produce locally relevant risk forecasts that draw upon local knowledge, values and priorities. This process of integration is critical: ultimately, it will determine the utility of large-scale hazard forecasts.

22 In this report 'exposure' is defined as the presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected by a hazardous event.
23 Miller, R.B. and Small, C. (2003).
24 Kienberger, S. and Zeil, P. (2005).
25 In this report 'vulnerability' is defined as the characteristics and circumstances of a community, system or asset that render it susceptible to the damaging effects of a hazard.
26 http://www.africariskview.org

This integration of centralised information with localised context and values is crucial, and will help to address the difficulty of comparing and allocating priority to diverse disaster risks across different communities and different situations. For example, the health and survival of livestock may have particular significance for the long-term survival and prosperity of a low-income family in an area vulnerable to drought, whereas the same livestock may well have much less importance in an industrialised or higher income setting.

6 Decision making and acting on risk information

While new science has considerable potential to improve the quality of information in the forecasting of many disasters, acting on that advice in a prudent and balanced way will be critical to reducing impacts. Decisions can be impeded by the very infrequent nature of some disasters as well as uncertainty in terms of severity, location and precise timing. Also, while it may be unpalatable, in some cases there may be grounds for accepting the risk because the costs of implementing DRR outweigh the benefits. There are no easy answers to such dilemmas and it will be for decision makers to consider when investment in enhanced resilience is justified. However, the following conclusions are relevant to a wide range of circumstances.

Much more work is needed to develop reliable measures of resilience which can be incorporated into risk models alongside data on hazards and vulnerability. These measures need to inform decision makers whether a given system is likely to be resilient to a particular future shock. An important aim is to build up a comprehensive picture of locations where resilience is lowest. This is a long-term goal and will require sustained effort from researchers to gather data. It is important to note that, while increasing resilience is almost always desirable, the benefits will not always outweigh the costs and decision makers will need to determine when investment in enhanced resilience is justified.

Options for addressing disaster risk include the following measures:

- Transferring the risk: remittance flows are expected to increase to US$467 billion by 2014, and can help to reduce the effects of disasters at both the macro and micro level. Preliminary estimates suggest that sub-Saharan African countries could raise more than US$5 billion from issuing diaspora bonds and even more by securitising future remittances. Much more use could be made of re-insurance to address disaster risk in developing countries, where neither formal nor informal risk management work well in isolation.
- Avoiding the risk: there is no clear consensus on the effectiveness of migration as a risk avoidance strategy. However, multiple lines of evidence demonstrate how early warnings have improved preparedness for populations threatened by floods and storms (e.g. Cyclone Sidr in Bangladesh). Mobile information and communication technology (ICT) is increasingly used to prepare for and respond to flooding and drought (e.g. in Bangladesh and in the UK) although more evaluation of its effectiveness is needed.
- Reducing the risk: the pressures of rapid urbanisation and population growth, particularly in East Asia and Latin America, will increase the demand for the provision of new infrastructure. But increases in the frequency and severity of natural hazards, particularly extreme events, in the future will lead to greater exposure of both new and existing infrastructure to damage. Science and engineering can respond to these challenges by informing the design, manufacture and monitoring of buildings which have economic and environmental benefits and which are resistant to the impacts of multiple hazards. Clear, legally established regulatory frameworks can help to incentivise private investors to invest in disaster-resilient infrastructure.
- Accepting the risk: this is the rational course if the costs of taking action outweigh the benefits. While the evidence for the effectiveness of hard infrastructure to protect against floods is strong, the economic case for other preventative measures against a range of hazards is uncertain primarily because the data needed to estimate the costs borne when hazards lead to disasters is rarely available. There is evidence that contingency planning for evacuation and shelter can be highly effective (e.g. in Bangladesh's response

to Cyclone Sidr[27]) although the evidence is less clear on the economic case, largely because data on costs incurred and avoided are not available.

The benefits of DRR clearly depend on which investments are made. Decision makers need to examine the merits of each possible measure and to decide, based on the evidence, whether or not it is preferable to accepting the risk. There are some challenges to making such evaluations.

- Whether a measure is preferred will depend on the value placed on human life, the discount rate and time horizon used, and the range of costs and benefits that are included in the analysis. Decision makers should not accept cost-benefit ratios uncritically, and scientists preparing them should make important assumptions clear. Over the coming decades this could lead to more refined and useful analyses being produced.
- There is a particular problem of 'deep uncertainty' when the reliability of information about the future is not known; i.e., while it is axiomatic that there is uncertainty in any forecast, there can also be uncertainty about whether the forecast itself is reliable. This makes it difficult for users of forecasts, from farmers to government ministers, to act confidently on forecasts and early warnings.

The challenges of evaluating costs and benefits can be partially addressed in the long term, but this will take several decades of committed action to build up bodies of evidence on two important issues: evidence of effectiveness for different interventions, and records of reliability for different forecasting models.

- In the long term, a solution to this deep uncertainty lies in building up track records of reliability for each forecasting approach (see Chapter 4). Decision makers could be 'intelligent customers' of probabilistic forecasts by requesting information about the reliability of those forecasts. Records of reliability need to be gathered and there may be a role for an 'honest broker' who can be relied upon to give a trustworthy assessment of a model's previous track record.
- Current understanding of best practice in disaster risk reduction is very limited. An evidence base on the effectiveness of different interventions would have value. This would require a shared, standardised repository of information which would provide an important resource to support decisions on DRR investments. Chapter 6 sets out how this might operate.

In the short term, there are ways in which policy makers can adapt to the uncertainty around the costs and benefits of possible interventions. These could be adopted immediately alongside the longer term effort described above.

- Policy measures can be designed to be flexible to accommodate different possible outcomes. For example, the response to the West Africa floods in 2008 was greatly enhanced because preliminary preparations for a possible full response were made in advance, based on probabilistic forecasts.
- Not all DRR interventions are expensive, and it would be wise to seek out and exploit co-benefits to DRR when making other investments, for example in infrastructure planning and in the management of ecosystems. These activities can provide direct economic benefits which justify their implementation. If future disaster risk is factored into the way in which investments are designed, additional DRR benefits may be obtainable at little additional cost.
- The private sector has much to contribute to DRR. Banks could make it easier and cheaper to send remittances, while insurers could expand the markets they serve. Mobile service providers could share data on the location of populations to harness the potential for mobile communications to provide early warnings; for example, involving collaborative initiatives between public and private sector. Social media enterprises could engage still further in the distribution of early warnings, and construction companies

27 Paul B.K. (2009).

could innovate to implement resilience. But realising this potential will require strong leadership from policy makers. What is required is a policy environment that incentivises investment in resilience to allow the creativity and flexibility of the private sector to act decisively to reduce future disaster risks.

7 Incentivising action

While the previous sections have highlighted the potential for scientific developments to improve the forecasting of disaster risk, incentivising their application will be difficult because of a number of barriers. These include the difficulty of investing in DRR for hazards that are unlikely to occur within political or societal time horizons, limitations in the current culture of DRR and possible organisational and governmental barriers.

What is needed is a culture change, not just among those who identify themselves as working on disaster risk, but among all those who are concerned with the sustainable development of developed countries. All decision makers, whether part of the government of those countries, businesses seeking to invest, aid and development funders or those in at-risk communities, need to consider the implications of their decisions for disaster risk. The new culture should routinely use the best available evidence on disaster risk to inform decisions on a wide range of issues. If this is not done, the benefits of development, whether jobs created or hospitals built, will remain at risk of being destroyed by future disasters.

As well as this general acceptance of the importance of disaster risk to a wider range of decisions, it is specifically desirable to promote a virtuous cycle in which:

- risk forecasts are routinely provided that take account of specific local vulnerabilities and priorities, include a wide range of possible impacts and have well-established and trustworthy records of reliability;
- decision makers use these forecasts to take decisions that sensibly weigh up costs and benefits;
- the effectiveness of the resulting DRR actions are routinely evaluated and made available for others to learn from.

However, if the best evidence is to be used by such a wide range of decision makers, it needs to be improved, and to become more usable. Many improvements are needed, but two are candidates for immediate action: the evidence should be better integrated and presented, and it should be clear how reliable the evidence is. Section 6.2 explores how these two areas might be taken forward in practice.

Strengthening integrated evaluation of future risks

Disaster risk reduction needs to learn from the transformation that the insurance industry has made over the past 30 years, and to move to a situation where the view of the future is firmly rooted in science-based risk models. This would form an essential basis for investing in disaster preparedness.

The aim would be to make a forward-looking, dynamic, DRR family of models that can forecast risk on multiple spatial and temporal scales. Driven by the needs of users, its forecasts should combine hazard forecasts with baseline exposure and vulnerability estimates, taking account of local values.

This is a highly multi-disciplinary objective and will require the creation of an institutional framework to oversee it. Users, risk modellers and natural and social scientists would all need to be involved. Maximising the use of existing datasets and models will be crucial and promoting data sharing and interoperability between existing modelling capabilities will be a vital task. The end result would be risk information that can be picked up and used easily by decision makers around the world who are not specialists in disaster risk.

Ensuring better information on effectiveness and reliability

Decision makers also need to know whether they can rely on the evidence presented. If it is a risk forecast, does the model that produced it have a track record of reliable predictions? If an intervention is being proposed, has that intervention been shown to work in similar situations? Decision makers will still often have to act in the absence of a track record of reliability or effectiveness, but they must at least be aware of the strength of the evidence that they are relying on.

Priority should be given to creating a shared, standardised repository of information on evaluations of interventions.

This shared asset would have two major components:

- User focus: it needs to hold the right information, and be readily accessible.
- Funders could to play a key role in requiring practitioners to deposit evaluations in the right format, and in the longer term, in driving up the quality of such evaluations. Establishing standards for best practice in interventions would be key.

Roles of stakeholders

For many organisations, incorporating future disaster risk into decisions being taken now on policy, investment and funding, could lead to significant benefits for the organisations themselves, and for the sustainable development of many countries.

- Policy makers are well placed to encourage a wide range of actions in others: clear signals that disaster risk is an important consideration for government will incentivise the private sector and NGOs to take fuller account of future disaster risk. 'Investment grade' policies and regulation can unlock investment and innovation, as discussed in section 5.6.1.1.
- Funders of DRR research and interventions can incentivise researchers and practitioners by giving priority to certain types of activity, and possibly even insisting on them as a condition of funding. The active promotion of three types of activity is particularly needed: long-term evaluation of effectiveness of DRR activities; longitudinal studies of indirect disaster impacts, such as mental health effects; and understanding disaster risk in cities.
- International bodies such as the United Nations also have key roles to play in incentivising co-operation between national and local organisations, especially in encouraging national governments to co-operate on the next generation of expensive scientific infrastructure, including high performance computing and earth observation satellites. They can also encourage and endorse decisions made by national or local leaders that address disaster risk, to help political leaders justify measures that may have up-front costs but long-term benefits. One example is the UNISDR 'Making Cities Resilient' campaign.
- The private sector also has strong incentives to act on future disaster risk, as this can directly improve business performance as well as demonstrating corporate social responsibility. If the insurance sector were to expand the coverage of its risk models, it would open up new markets for insurance in developing economies. Construction firms could gain competitive advantage by developing infrastructure designs that are more resilient to disaster risk for the many cities which will build new infrastructure over the next 30 years.

Over the next two years, there is a unique opportunity for stakeholders to show leadership on the issue of disaster risk. This is because a range of important political and practical developments in this area are on the horizon. The issue has already been highlighted as a priority by the UN Secretary General and the General Assembly and as a key theme by the Mexico G20 presidency. But there is a real opportunity arising from the alignment of timetables that is imminent in 2015, when the successor to the Hyogo Framework for Action

(HFA) will need to be in place[28], and when a new set of development goals are planned to follow on from the Millennium Development Goals. The process of setting out this post-2015 landscape is already underway. If a clear agenda for disaster risk can be rapidly agreed, and allied with the wider post 2015 process, there are likely to be benefits from the strong focus on this wider global development agenda to help drive specific actions.

8 Conclusion

The overall picture is one of increasing challenges ahead. However, this Report has shown that disaster and death are not the inevitable consequences. It is possible to stabilise disaster impacts and save both lives and livelihoods given political leadership and concerted action by the wide range of stakeholders who have a part to play.

With more people at risk than ever from natural hazards, and the prospect of further increases over the next 30 years, the future challenges are considerable. However, these are balanced by a number of positive factors. In particular, science has the potential to play a key role in providing better assessments of future hazards and their impacts, in developing more effective early warning systems, at least in some cases, and in informing better decisions for disaster risk reduction. Perhaps most importantly, the range of international policy developments outlined above means that the time is now ripe for a wide range of stakeholders to harness science more effectively, and to work in concert and individually to improve DRR, both for the benefit of vulnerable communities and, indeed in their own interests.

It is hoped that the evidence and analysis set out in the full Foresight Report, as well as the various evidence papers, will be of use to the wider community of decision makers both in stimulating a virtuous circle of disaster risk reduction, and also in informing priorities for action.

28 The HFA is a 10-year plan, led by UNISDR, which aims to make the world safer from natural hazards. It was adopted by 168 Member States of the United Nations in 2005 at the World Disaster Reduction Conference. More detail is available at http://www.unisdr.org/we/coordinate/hfa.

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