Economic Analysis

Guidance Note 8

Tools for Mainstreaming Disaster Risk Reduction *is a series of 14 guidance notes for use by development organisations in adapting programming, project appraisal and evaluation tools to mainstream disaster risk reduction into their development work in hazard-prone countries. The series is also of relevance to stakeholders involved in climate change adaptation.*

This guidance note addresses the issue of economic analysis, providing information on how to ensure that disaster risk and related options for reducing vulnerability are adequately and systematically examined from an economic perspective in scoping development projects. The note also provides direction on the economic appraisal of disaster risk reduction projects. This guidance note is intended for use by economists in development organisations, complementing their existing economic analysis guidelines.

1. Introduction

The basic purpose of project-based economic analysis is to help design and select projects that contribute to the welfare of a country and its people.[1] Cost–benefit and related economic appraisal approaches are applied to determine the highest return to investment in a project, facilitate a rational comparison of available options and ensure that investment decisions are accountable. Economic analysis is also potentially useful in identifying and clarifying the issues involved in making particular decisions.

Consideration of disaster risk concerns as part of the economic appraisal process is an essential step in ensuring that development gains in hazard-prone countries are sustainable and in highlighting related issues of responsibility and accountability. Natural hazards can have potentially serious implications for the economic viability of development projects, damaging or destroying physical infrastructure and capital equipment, and resulting in additional indirect and secondary project and broader socio-economic effects. However, such losses are not inevitable. Indeed, there can be potentially high returns to disaster risk reduction investments in hazard-prone areas (Box 1), in the form of both specific disaster risk reduction projects and the disaster-proofing of other development projects. Such investments can also have significant additional indirect benefits for the broader economy and sustainable development (Box 2).

Box 1 Disaster risk reduction can 'pay'

- One US dollar spent by the United States Federal Emergency Management Agency (FEMA) on hazard mitigation saves an estimated US$ 4 on average in future benefits according to a study of FEMA grants (including for retrofitting, structural mitigation projects, public awareness and education and building codes).[2]
- A planned polder system in Peru, supported by Gesellschaft für Technische Zusammenarbeit (GTZ), the German technical development agency, whereby floodwaters would be diverted in a polder retention basin, has been calculated to have an estimated benefit-to-cost ratio of 3.8. A GTZ-supported integrated water management and flood protection scheme in Indonesia has an estimated ratio of 2.5.[3]

1 Belli et al. (1998).
2 MMC/NIBS (2005).
3 Mechler (2005).

- Non-governmental organisation (NGO) interventions to reduce the impact of flooding in Bihar and of flooding and drought in Andhra Pradesh, India, have estimated benefit–cost ratios of 3.8 and 13.4, respectively.[4]
- A Vietnam Red Cross mangrove planting programme in eight provinces in Vietnam to provide protection to coastal inhabitants from typhoons and storms cost an average US$ 0.13 million a year over the period 1994 to 2001, but reduced the annual cost of dyke maintenance by US$ 7.1m. The programme also helped save lives, protect livelihoods and generate livelihood opportunities.[5]
- Spending 1 per cent of a structure's value on vulnerability reduction measures can reduce probable maximum loss from hurricanes by around a third in the Caribbean, according to regional civil engineering experts.[6]

Box 2 Macroeconomic impacts of disasters

Risk reduction investments play a collective, broader role in reducing macroeconomic vulnerability to natural hazards and supporting efforts to alleviate poverty. These benefits are typically too far removed from individual disaster risk reduction measures to be taken into account in project economic appraisal. However, they may be an important consideration in determining a development organisation's broader strategic areas of focus in hazard-prone countries (**see also Guidance Note 4**).

Major disasters can have severe negative short-term socio-economic impacts. Disasters result, for example, in loss in productive capacity and thus output and employment opportunities. They may also create balance of payments and budgetary pressures (**see Guidance Notes 4 and 14**), disrupt financial and credit markets and exacerbate poverty (**see Guidance Note 3**). Longer-term impacts of disasters are more difficult to determine empirically but may be significant, in part as disasters reduce the pace of capital accumulation, destroying existing productive and social capital and diverting scarce resources away from new investment. As such, disasters can represent a threat to both short-term economic stability and long-term sustainable development. Moreover, macroeconomic vulnerability to natural hazards often increases, rather than declines, during earlier stages of economic development (**see Guidance Note 3**).

However, high macroeconomic vulnerability is by no means inevitable and governments can take various steps to promote greater resilience, including by influencing the composition of economic activity and fostering strong underlying stability. Detailed studies of individual countries provide further evidence on the macroeconomic impacts of disasters, implications for levels and patterns of development and specific options for strengthening resilience.

For further discussion, see Benson, C. and Clay, E.J., *Understanding the Economic and Financial Impacts of Natural Disasters.* Disaster Risk Management Series No. 4. Washington, DC: World Bank, 2004. http://www-wds.worldbank.org/servlet/WDS_IBank_Servlet?pcont=details&eid=000012009_20040420135752

Current state of the art

There has been little effort to incorporate disaster risk concerns into the economic analysis of development projects or to use tools of economic analysis to examine possible ways of strengthening their hazard resilience, even in high-risk areas. There have also been few detailed economic analyses of risk reduction projects, particularly in a developing country context. In consequence, the collective evidence on the net benefits of risk reduction is limited and highly context specific. Related development organisation manuals on economic analysis similarly provide little guidance on analysis of disaster risk.

The paucity of evidence on the benefits of disaster risk reduction has proved a major stumbling block in attracting the interest and commitment of policy-makers to disaster risk reduction. Economic criteria are not the only ones by which projects are judged. Indeed, only multilateral lending agencies routinely undertake some form of economic analysis as part of their project appraisal process. And ultimately, even for these organisations, although minimum

4 Cabot Venton and Venton (2005).
5 IFRC. *World Disasters Report: Focus on reducing risk*. Geneva: International Federation of Red Cross and Red Crescent Societies, 2002.
6 World Bank. *Managing Catastrophic Risks Using Alternative Risk Financing and Insurance Pooling Mechanisms.* Discussion draft. Washington, DC: World Bank, Finance, Private Sector and Infrastructure Department, Caribbean Country Management Unit, Latin America and Caribbean Region, 2000.

internal rate of returns often have to be satisfied, high economic returns may be less important than, say, the contribution of a project to poverty reduction. However, in the face of tight budget constraints and many competing demands for public resources, there is widespread pressure to demonstrate that aid resources are well spent. Without ready access to data on the potential economic returns to investments in risk reduction, many are unwilling to even consider such investments. They also often fail to appreciate the potential importance of ensuring that other development projects in hazard-prone countries are adequately protected against natural hazards.

Advocated good practice

Two essential steps are required as part of the economic appraisal process to ensure that disaster risks are adequately assessed and managed:

- Disaster risk should be considered as part of the economic appraisal process as a matter of course in the design of all projects in hazard-prone areas.
- Related economic appraisal, incorporating analysis of disaster risk, should be applied early in the project cycle so that findings can be taken into account in the design of both disaster risk reduction projects and other development projects in hazard-prone areas, helping to strengthen resilience against natural hazards.

2. Basic steps in merging disaster risk concerns into economic analysis

Measures required to ensure that disaster risk and related options for reducing vulnerability are adequately and systematically examined and addressed at each step in the economic appraisal of a project are outlined below and summarised in Figure 1. This guidance note is intended to supplement existing guidelines on economic analysis, focusing specifically on where and how to build disaster-related concerns into account rather than providing full, comprehensive guidance on all aspects of economic appraisal. Analysis of disaster risk and related risk reduction measures raises a number of potentially complex issues, justifying this special focus.

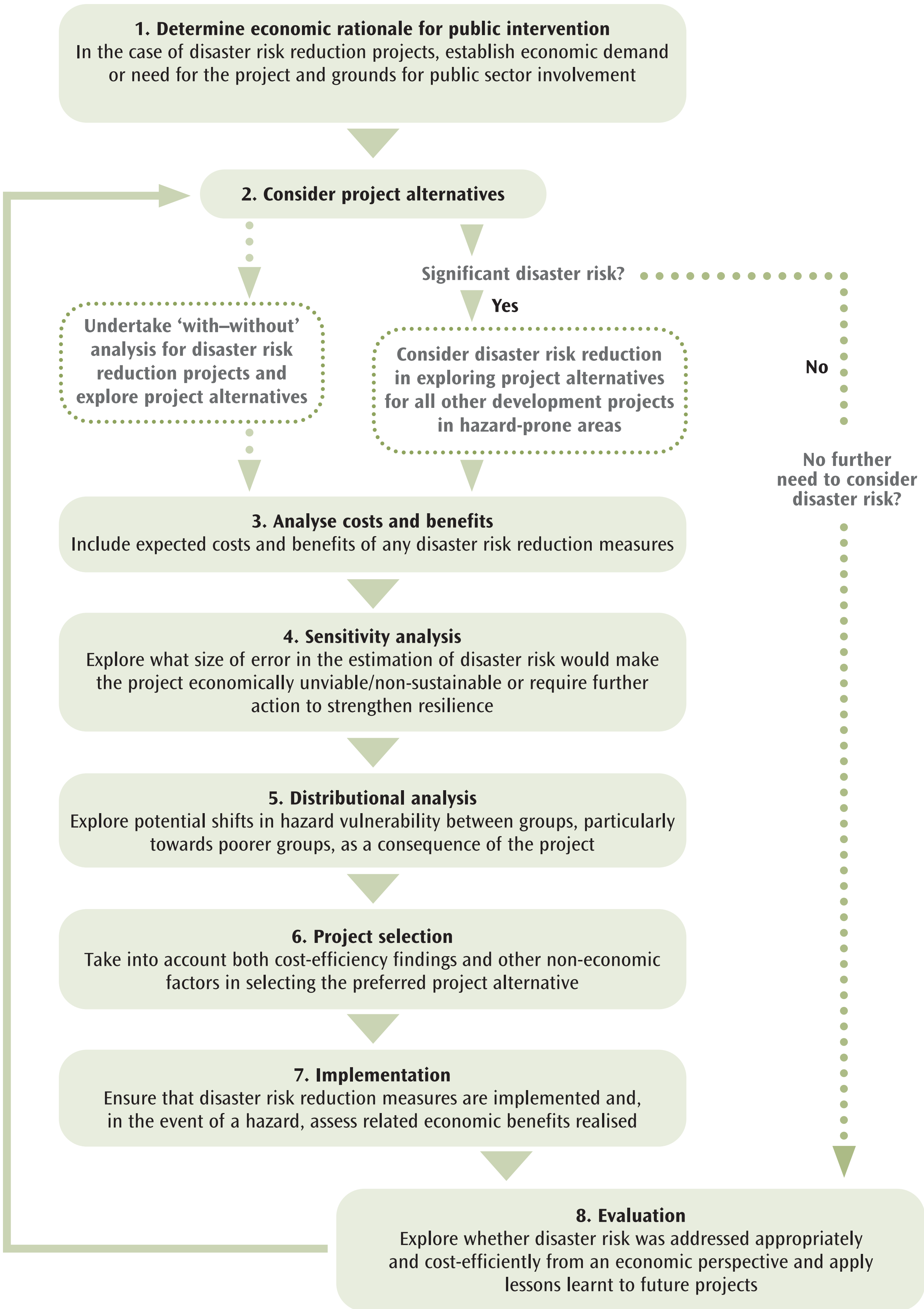
Step 1. Determine economic rationale for public intervention

In appraising potential disaster risk reduction projects, establish the economic demand or need for the project and the grounds for public sector involvement. Linkages to the development organisation's country strategy should also be established. Disaster risk concerns do not need to be considered at this preliminary stage in the economic appraisal of other development projects that do not have an explicit disaster risk reduction objective.

The economic case for a disaster risk reduction initiative is typically based on the need to reduce potential direct and indirect losses, rather than to generate a continual flow of positive benefits. As such, it can be difficult to establish a demand curve for such projects. Instead, it may be more appropriate to base demand analysis on estimates of the scale of the disaster reduction intervention that would be required to reduce potential losses to acceptable levels (as defined within the context of the project) and/or ensure desired safety standards. Alternatively, it may be possible to establish a notional demand curve based on a user survey of willingness to pay.

As regards the rationale for public sector involvement, some disaster risk reduction measures may be justified on the basis of the fact that they constitute public goods – that is, are non-rival in consumption (users do not reduce the supply available to others) and non-excludable – and so markets fail to provide them. Scientific forecasting and some forms of dissemination of disaster warnings, for instance, can be characterised as such. Others may be justified on grounds of equity. There are additional moral obligations on the part of government to prevent loss of human life.

Figure 1 Integration of disaster risk concerns into economic appraisal



Step 2. Consider project alternatives

In the case of proposed disaster risk reduction projects, analyse the 'with–without' project situation – that is, the impact of a hazard event with and without the project – and also consider alternative ways of addressing the project objective. In the case of other proposed development projects to be undertaken in hazard-prone areas, consider disaster-related issues in examining alternative project designs and scales of intervention, in terms of both the vulnerability of the project to natural hazards (e.g., the implications of decisions relating to alignment, surface type and drainage of roads for the level of vulnerability to flooding) and the impact of the project on disaster risk (e.g., a communications project that could also benefit the transmission of an early warning system or, adversely, a fisheries project that could also result in the destruction of mangroves) in examining project alternatives. (**See Guidance Notes 2 and 7** regarding sources of information on the types and probabilities of hazards faced.)

The economic analysis of alternatives and the subsequent analysis of costs and benefits (see Step 4) need to take account of the following factors:

- A reduction in disaster risk can sometimes be achieved via a choice of highly contrasting methods, ranging from large-scale technical projects to small-scale community-based initiatives and from engineering to social interventions. Analysis of alternatives should entail a careful, broad-minded examination of all possible approaches, rather than focusing solely on more minor adjustments in technical design, scale or levels of protection.
- Many of the benefits of any disaster risk reduction measures, whether undertaken in the context of a disaster risk reduction project or as part of another type of development project, are related to the direct and indirect losses that will not ensue should the related hazard event occur over the life of the project, rather than streams of positive benefits that will take place, as would be the case for other investments.
- In some cases, however, disaster risk reduction initiatives can generate some positive streams of benefits, for instance, where investments in irrigation to reduce the impact of drought result in a switch in cultivation to higher-yielding crops. Some projects even have explicit non-disaster, as well as disaster-related, objectives: for example, a dam may be planned both for flood control purposes and as part of a hydro-electricity scheme. Positive benefits should be taken into account in the economic analysis.
- Levels and forms of vulnerability may change considerably over the life of a project, particularly in developing countries undergoing rapid socio-economic change and/or high demographic growth. These changes, which can be both positive and negative, need to be considered in exploring potential flows of net benefits resulting from related disaster risk reduction measures.
- Predicted impacts of global warming on the frequency and intensity of climatological hazards over the life of the project should, likewise, be taken into account.
- The role of risk reduction measures in determining the outcome of above-design hazard events[7] should be explored. In some such cases, they would still reduce levels of loss but in others, they could exacerbate them (for instance, where flood control measures have effectively encouraged the development of a flood plain).
- Development projects can transfer risk to another area, either intentionally (e.g., in the case of deliberate diversion of floodwaters) or unintentionally (e.g., in the case of the construction of infrastructure blocking drainage of water – **see Guidance Note 7**, Box 1). The analysis should take account of any such potential positive or negative externalities. The geographical boundaries of analysis, conventionally defined for purposes of cost–benefit analysis as a country, may need to be broadened in order to do this. The impact of the project on different groups, including non-beneficiaries, also needs to be carefully explored.
- Potential benefits of disaster risk reduction initiatives may not be fully realised, particularly where they are dependent on public compliance and capability to respond appropriately – for instance, to take appropriate action when a disaster warning is received – or proper upkeep and maintenance of related structures. Estimation of benefits should therefore be realistic.

Stakeholder analysis undertaken as part of the analysis of alternatives should similarly explore disaster risk and related options for strengthening the resilience of proposed outcomes. Beneficiary and non-beneficiary groups should be included in this process to determine relevant concerns, including the potential impact of different project alternatives on the vulnerability of the various groupings to natural hazards.

Step 3. Analyse costs and benefits

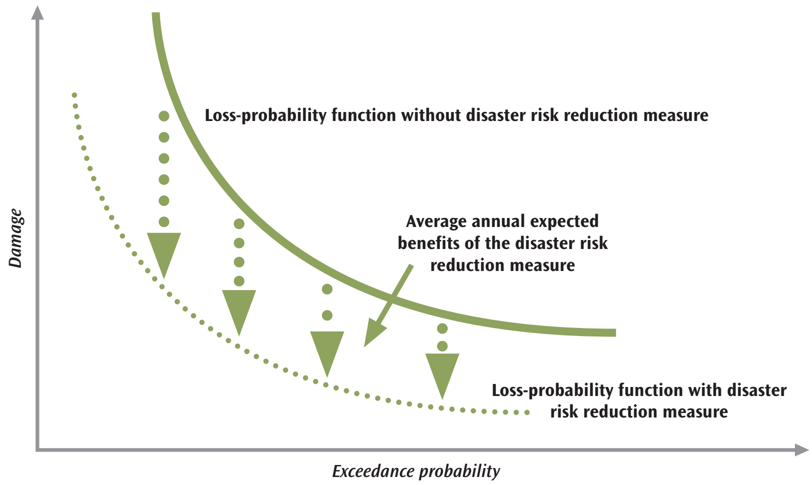
Take the cost of any proposed disaster risk reduction measures and the monetary value of the expected related flow of direct and indirect benefits into account in determining if a project is economically justified. Estimation of disaster risk reduction-related costs is normally straightforward. The estimation of benefits is more complicated as they

7 Hazard events of a greater magnitude than those against which the risk reduction measure is intended to provide protection (e.g., a 1 in 100-year flood, rather than the design 1 in 50-year flood).

are necessarily probabilistic, with the actual level of benefits realised dependent on the degree of severity of hazard events – if any – occurring over the life of the project. Moreover, little related information may be available on the likely frequency and intensity of potential hazards. Various methods therefore exist for incorporating risk and the related benefits of disaster risk reduction into economic analysis, the selection of which depends on the level of availability of hazard information.

Probability-based approaches. In cases where better hazard information is available or more funding is on hand to invest in estimating hazard probabilities, a more rigorous analysis of benefits can be undertaken. In such cases, an exceedance probability curve must first be obtained, indicating the probability of occurrence of different intensities of the hazard in question at a given location. A vulnerability analysis of the resilience of the assets or livelihoods that would be given some protection by the disaster risk reduction measures should then be undertaken, both with and without that measure. Finally, the vulnerability and exceedance probability curves should be combined to generate the loss-probability curves, indicating the probability of differing levels of loss with and without the disaster risk reduction measure. The area under each loss-probability curve represents average annual expected losses. Average annual expected benefits of a disaster risk reduction measure are represented by the area between the two loss-probability curves (Figure 2).[8]

Figure 2 Expected benefits of a disaster risk reduction measure



Exceedance probability curves may be available already, based on historical record and/or computer modelling (**see Guidance Note 2**). However, they often have to be estimated. Ideally, such estimates should be based on at least eight hypothetical hazard events, ranging from very low to very high probability. At an absolute minimum, three data points are required relating to the most likely, minimum possible and maximum possible events, so generating a triangular distribution. Levels of vulnerability to each event must then be assessed and a loss-probability curve derived. Local knowledge may be an important source of information in assessing vulnerability, particularly in relation to higher frequency hazards.

Alternatively, it may be preferable to derive the loss-probability curve from actual events, based on historical losses adjusted to reflect shifts in forms and levels of vulnerability over time and converted into current prices (see Box 3). Again, data on at least three events are required. These data could be complemented by a survey of the impact of past events on the intended beneficiary group (assuming a hazard event has occurred in recent times). In other cases, it may sometimes be possible to avoid estimation of the loss-probability curve entirely (see Box 4).[9]

Box 3 **Historical damage assessment data – a cautionary note**

Data on the impact of disasters are often weak, presenting an incomplete and, in parts, sometimes highly inaccurate record of events. As such, they constitute a potentially unreliable basis for estimating loss-probability functions.

8 See Parker et al. (1987) and Mechler (2005) for further guidance.
9 For further detailed guidance on the generation of loss-probability curves, including worked examples, see Mechler (2005).

The data typically focus on direct, physical losses, primarily based on official damage assessments. Even these data may be associated with a number of difficulties, for example:

- Many countries lack standard, comprehensive and systematic guidelines for use in estimating the costs of disasters. Even within a particular country, there may be discrepancies between different disasters in terms of the nature of data collated and methods for valuing loss.
- Coverage of assessments is typically partial, with involved government, donor and civil society groups only covering areas where they may be able to provide relief and rehabilitation assistance. Damage to the private sector may be largely ignored.
- Additional data on private losses are provided by the insurance industry but only cover insured losses which, in the case of developing countries, may represent a tiny proportion of total private losses.
- Damage assessments are commonly undertaken by officials and volunteers on the ground, often with little prior specialist training.
- Damage assessments are typically finalised very rapidly, often only a few months after a disaster has occurred and before its full impact is revealed.

The broad validity of loss-estimate data and the overall direction of any bias should therefore be explored before using historical data on losses to derive loss-probability functions.

A disaster can also have many flow or knock-on effects, commonly categorised as indirect and secondary effects. Indirect effects relate to disruption to the flow of goods and services, including, for instance, reduced output, loss of earnings and job losses. Secondary effects concern both the short- and the long-term broader socio-economic impacts of a disaster, such as on gross domestic product growth, fiscal and monetary performance, indebtedness and the scale and incidence of poverty. These indirect and secondary effects should also be carefully explored. However, in economic terms, direct physical losses are valued as the future flow of resources from the affected assets, implying that aggregate figures on total direct, indirect and secondary effects should be carefully scrutinised for any double counting.

Box 4 Case examples on estimating loss-probability functions

Worked cost–benefit analyses have employed a variety of methods to estimate loss-probability functions and related benefits of disaster risk reduction initiatives, in some cases based on detailed quantitative information and in others simplifying assumptions. For instance:

- A GTZ cost–benefit analysis of an integrated water management and flood protection scheme in Semarang, Indonesia was able, somewhat unusually, to take advantage of existing exceedance probability curves for riverine and coastal flooding in the project area and surveys of exposed assets. Future increases in exposure were assumed to be in line with projected population growth.
- A cost–benefit analysis of a flood protection project in Piura, Peru, undertaken as part of the same GTZ study, employed a backward-looking approach. The analysis was based on actual damage data from floods in 1982–1983 and 1997–1998 combined with information on the frequency and severity of El Niño events over the past 150 years, to which higher levels of rainfall in the project area are closely correlated. Damage data were disaggregated to determine levels of loss in the project area. Projections of future losses were adjusted to take account of changes in land use, increasing assets and enhanced resilience, the latter reflecting dyke improvements since the 1982–1983 flood and the installation of an early warning system since the 1997–1998 flood.
- An analysis of an NGO intervention to reduce the impact of flooding in Bihar, India, by raising hand pumps and supporting evacuation was based on the simplifying assumption that annual flood-related losses in the absence of the intervention would be the same every year over the life of project – that is, would occur with 100 per cent certainty. This approach was justified on the basis of the argument that although the level of flooding varied each year, it consistently reached a sufficient height to block hand pumps and require evacuation. Sensitivity analysis was used to explore the implications of longer (four-month) and shorter (two-month) periods of flooding, rather than the assumed three months.

Sources: Cabot Venton and Venton (2005); Mechler (2005).

Limited information approaches. In situations where information is limited and restricted resources available for the economic analysis, alternative less rigorous approaches may be pursued. However, these approaches should be applied with considerable caution and care.

In situations where there is high uncertainty about levels of risk but the magnitude of hazard events is potentially great, the pay-off or cut-off period approach may be applied. Under this approach, projects are assessed on the basis of whether they will generate sufficient net benefits over a specified, relatively short, period of time, as little as two to three years. Costs and benefits beyond the cut-off period are ignored. Alternatively, under the discount-rate adjustment approach, less weight is given to increasingly uncertain future benefits and costs by adding a risk premium to the discount rate. Game theory approaches offer a third option, following either 'maximin-gain' or 'minimax-regret' strategies. Under the former, the project alternative that gives the highest return in the worst-case scenario is selected. The latter involves selection of the project giving the smallest sum of possible losses. Under a fourth approach, sensitivity analysis, the value of key uncertain parameters is altered (see, also, below).[10]

Valuing benefits. Regardless of the approach selected for incorporating risk and the related benefits of disaster risk reduction into economic analysis, the issues listed above under Step 2 need to be taken into account in estimating benefits. In addition, the following factors should be borne in mind:

- **Indirect benefits.** The analysis should only take account of changes in indirect losses that can be clearly attributed to the project and that are not already counted as direct benefits (see Box 3). In some cases, input–output models capturing the inter-sectoral forward and backward linkages between different sectors in an economy may be helpful in determining indirect benefits. However, simple heuristics assuming fixed ratios of total direct to total indirect losses should be avoided. Although a few such ratios have been calculated, too few of them are available to be able to ensure that the selected ratio is in keeping with the particular nature of potential damage, prevailing socio-economic circumstances in the affected country and so forth.
- **Intangibles.** Risk reduction initiatives can also generate intangible benefits – that is, benefits relating to non-traded goods and services for which there is no commonly agreed method of monetary valuation. Intangible benefits include, for instance, damage to buildings of cultural or historical significance, disruption of schooling and psychological trauma. The literature on cost–benefit analysis of disaster risk reduction measures generally favours use of the contingent valuation method for valuing intangible benefits, cautioning against the use of other tools that have been developed for this purpose.[11] Under the contingent valuation method, respondents to a survey are asked how much they would be willing to pay for a clearly specified change, such as the additional protection to a historical building provided by a particular structural mitigation investment. Cost-effectiveness analysis provides an alternative method for analysing alternatives for projects that entail the flow of substantial non-monetary benefits or intangibles and where a decision has already been taken to proceed with a particular project. Under this approach, project inputs are valued in monetary units and outputs in physical units, with the least-cost method of achieving particular targets and objectives then selected (Box 5).

Box 5 Cost-effectiveness analysis: Seismic retrofitting in Romania

Cost-effectiveness analysis was applied to determine the selection of possible seismic retrofitting options for each sub-project under the seismic retrofitting component of a World Bank hazard risk mitigation and emergency preparedness project in Romania. The selection of sub-projects, in turn, was based on the functional importance of different public facilities within the emergency response system, their relevance in terms of life safety, their readiness for implementation and the cost of retrofitting, which had to total under 60 per cent of replacement cost for selection.

Source: World Bank. *Project Appraisal Document on a Proposed Loan in the Amount of US$150 million and a grant from the Global Environment Facility in the Amount of US$7 million for Government of Romania for a Hazard Risk Mitigation and Emergency Preparedness Project.* Report No: 282 17 RO. Washington, DC: World Bank, Environmentally and Socially Sustainable Development Unit, Europe and Central Asia Region, 2004.

10 See Kramer (1995), Parker et al. (1997) and OAS (1991) for further discussion on the relative merits and pitfalls of these various approaches.
11 See Penning-Rowsell et al. (1992) and Handmer and Thompson (1996) for an in-depth discussion.

- **Injury and loss of life.** Valuation of injury and loss of human life, both of which are further examples of intangibles, is a particularly contentious issue, involving ethical and technical difficulties. The 'Value of a Statistical Life' approach, based on contingent valuation and willingness to pay, is generally considered the best tool in this regard. Under this approach, the value individuals place directly on reducing their own and others' risk of death and injury is summed across all those that might be affected by a particular event.[12] In other situations it may be necessary to compare different types of potential projects in terms of lives saved (e.g., malaria control versus earthquake-proofing of schools). In such cases, a Disability Adjusted Life Years (DALY) type approach, taking into account the effect of interventions on life expectancy and quality of life, could be used to measure their relative cost-effectiveness and aid decision-making.[13]

Step 4. Sensitivity analysis

In cases where a probability-based approach has been taken, explore how large errors in the estimated disaster risk would have to be either to make the project economically unviable or non-sustainable or to require further action to strengthen resilience. Sensitivity analysis is necessary because derivation of loss-probability curves will always entail some degree of uncertainty.

Sensitivity analysis of estimates of disaster risk is particularly important for projects located in areas undergoing rapid socio-economic change (e.g., due to demographic growth or shifts in productive activities) and thus where vulnerability to natural hazards could alter significantly over the life of the project. It is also important where the frequency and severity of hazard events could be altered by climate change.

The potential indirect impact of a disaster on other uncertain variables in the project analysis, such as the price of critical inputs or outputs[14] and the availability of government counterpart investment and recurrent cost funding, should also be explored as part of the sensitivity analysis for all proposed projects in hazard-prone areas, although due care should be taken to avoid problems of covariance in any formal statistical analysis. In addition, implications of other risks (such as inadequate maintenance of project facilities) for disaster risk should be considered.

For large projects and those with net present values (NPVs) close to zero, a more rigorous sensitivity analysis may be required, varying the values of all key variables simultaneously to generate a probability distribution function of a project's expected economic NPV.

Step 5. Distributional analysis

In examining the extent to which intended beneficiaries will actually benefit from the project, explore potential shifts in vulnerability to natural hazards between groups – particularly towards poorer groups and non-beneficiaries – as a consequence of the project. For instance, flood protection schemes may attract new residents into flood plains, potentially forcing up land prices and pushing intended beneficiaries (i.e., existing, poorer households) away into other vulnerable areas (**see Guidance Note 3**). Distributional weights could be applied to take account of equity considerations, attaching higher weights to impacts benefiting the poor, although in practice there has been little, if any, application of this quantitative tool to the analysis of disaster risk reduction projects.

Step 6. Project selection

Take account both of cost-efficiency findings and also of rights to safety and protection, levels of risk aversion and other technical, social and environmental factors in selecting the preferred project alternative. The results of the economic analysis help inform decisions on project alternatives but are not the sole criterion on which they rest. From an economic perspective, project alternatives can be compared on various bases, such as their mean NPV; using a mean–variance analysis, which takes into account the degree of dispersion around the mean; or using a safety-first analysis, which seeks to maximise the expected NPV conditional on the risk of benefits falling below a critical level being as small as possible.

Step 7. Implementation

Ensure that any specified disaster risk reduction measures are implemented and, should a hazard event actually occur, assess related economic benefits (in effect, losses averted) resulting as a consequence of these measures.

12 For further discussion, see Dixon, J.A., *The Economic Valuation of Health Impacts*. Washington, DC: World Bank, 1998. Available at: http://siteresources.worldbank.org/INTEEI/214574-1153316226850/20486375/EconomicValuationofHealthImpacts1998.pdf; and Mechler (2005).

13 For further information, see DFID, *DALYs and Essential Packages: Briefing Paper*. London: Department for International Development (UK), Health Systems Resource Centre, 2000. Available at: http://www.dfidhealthrc.org/shared/publications/Briefing_papers/DALYS.PDF

14 Implications of potential disaster-induced short-term rises in prices of key inputs should also be explored in determining the nominal cash flow as part of the financial analysis.

Step 8. Evaluation

With the benefit of hindsight, explore whether disaster risk was addressed appropriately and cost-efficiently from an economic perspective; how any disasters occurring over the course of the project affected its outcome and effectiveness; and whether the sustainability of the project's achievements are potentially threatened by future hazard events.

Box 6 FEMA's mitigation benefit–cost analysis (BCA) toolkit

FEMA has developed a series of software, written materials and training for use by FEMA grants applicants to structure and guide the cost–benefit analysis of disaster risk reduction measures. The suite of software can be applied to the analysis of earthquakes, wildland/urban interface fires, riverine and coastal floods, hurricanes and tornados. A related helpline has been established to provide technical support.

For further information, see FEMA (2006).

3. Critical factors for success

- *Full exploitation of economic appraisal tools.* Most fundamentally, economic analysis needs to be regarded as a key tool for designing projects and applied accordingly. If, instead, it is simply viewed as a means for calculating net present values and economic rates of return to satisfy project approval requirements, its potentially important contribution in analysing and addressing disaster risk as part of project design will be lost.
- *Understanding of the potential importance of assessing disaster risk.* Increased awareness of the potential importance of addressing disaster risk as part of the economic appraisal process is critical. To help achieve this, international development organisations should encourage the careful documentation and collation of evidence on the economic returns to investment in risk reduction, possibly via research but also, most critically, by assessing hazard risks and potential returns to mitigation as a matter of course in designing all projects in hazard-prone areas. Ideally, this information should be pooled into a single central global database, allowing more general, validated conclusions to be drawn on the benefits of mitigation.
- *Supportive policy environment.* Underlying policy commitment to disaster risk reduction is also required in order to strengthen the attention paid to related concerns in project design.
- *Pragmatic approach to analysis.* In the interests of cost and time, emphasis should be placed on relatively 'rough and ready' data collection and analysis, rather than more academic, full-blown cost–benefit investigation.

Box 7 Hazard and disaster terminology

It is widely acknowledged within the disaster community that hazard and disaster terminology are used inconsistently across the sector, reflecting the involvement of practitioners and researchers from a wide range of disciplines. Key terms are used as follows for the purpose of this guidance note series:

A *natural hazard* is a geophysical, atmospheric or hydrological event (e.g., earthquake, landslide, tsunami, windstorm, wave or surge, flood or drought) that has the potential to cause harm or loss.

Vulnerability is the potential to suffer harm or loss, related to the capacity to anticipate a hazard, cope with it, resist it and recover from its impact. Both vulnerability and its antithesis, *resilience*, are determined by physical, environmental, social, economic, political, cultural and institutional factors.

A *disaster* is the occurrence of an extreme hazard event that impacts on vulnerable communities causing substantial damage, disruption and possible casualties, and leaving the affected communities unable to function normally without outside assistance.

Disaster risk is a function of the characteristics and frequency of hazards experienced in a specified location, the nature of the elements at risk, and their inherent degree of vulnerability or resilience.[15]

Mitigation is any structural (physical) or non-structural (e.g., land use planning, public education) measure undertaken to minimise the adverse impact of potential natural hazard events.

Preparedness is activities and measures taken before hazard events occur to forecast and warn against them, evacuate people and property when they threaten and ensure effective response (e.g., stockpiling food supplies).

Relief, rehabilitation and *reconstruction* are any measures undertaken in the aftermath of a disaster to, respectively, save lives and address immediate humanitarian needs, restore normal activities and restore physical infrastructure and services.

Climate change is a statistically significant change in measurements of either the mean state or variability of the climate for a place or region over an extended period of time, either directly or indirectly due to the impact of human activity on the composition of the global atmosphere or due to natural variability.

Further reading

ADB. *Handbook for Integrating Risk Analysis in the Economic Analysis of Projects*. Manila: Asian Development Bank, 2002.

Belli, P. et al. *Handbook on Economic Analysis of Investment Operations*. Washington, DC: World Bank, Operational Core Services Network, Learning and Leadership Center, 1998.

Cabot Venton, C. and Venton, P. *Disaster preparedness programmes in India: A cost benefit analysis.* Humanitarian Practice Network Paper 49. London: Overseas Development Institute, 2004. Commissioned and published by the Humanitarian Practice Network at the Overseas Development Institute (ODI).

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15 The term ‘disaster risk’ is used in place of the more accurate term ‘hazard risk’ in this series of guidance notes because ‘disaster risk’ is the term favoured by the disaster reduction community.

This guidance note was written by Charlotte Benson. The author would like to thank Sheila Ahmed (DFID), Tom Crowards (DFID), Vanessa Head (DFID), Dougal Martin (Inter-American Development Bank), Reinhard Mechler (International Institute for Applied Systems Analysis), Courtenay Venton (Environmental Resources Management, UK), members of the project Advisory Group and the ProVention Consortium Secretariat for their invaluable advice and comments. Financial support from the Canadian International Development Agency (CIDA), the United Kingdom's Department for International Development (DFID), the Royal Ministry of Foreign Affairs, Norway and the Swedish International Development Cooperation Agency (Sida) is gratefully acknowledged. The opinions expressed are those of the author and do not necessarily represent the views of the reviewers or funding bodies.

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