Guide Book
Session 7:
Disaster Risk Management

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Objectives

After this session you should be able to:

- Explain how risk analysis forms part of the overall risk management process
- Understand the factors involved in risk perception and evaluation
- Outline how spatial risk information plays a role in risk governance, risk communication and risk visualization
- Define which structural and non structural mitigation measures can be applied for different types of hazards.
- Carry out a cost benefit analysis to evaluate the most suitable risk reduction measures
- Understand how risk assessment forms part of a Strategic Environmental Assessment

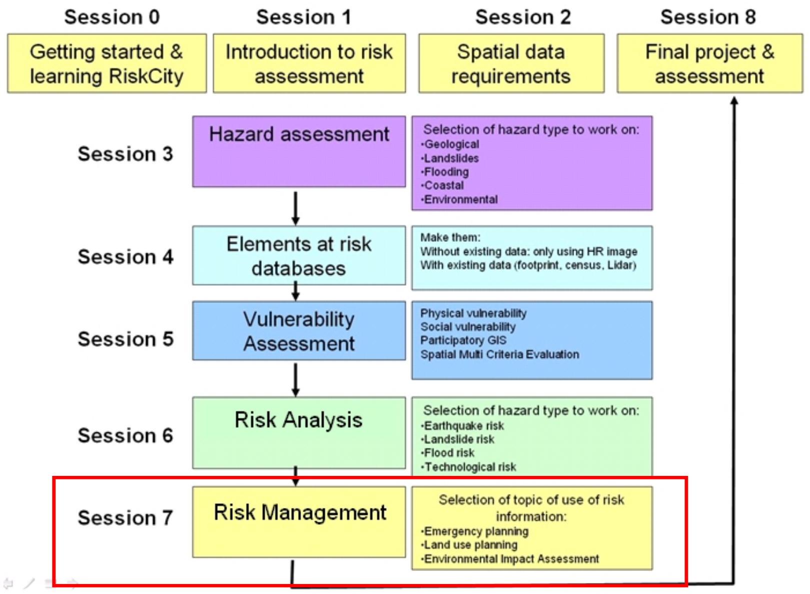
In this session you will see how risk information can be used in Disaster Risk Assessment. We will start by looking at the aspects of Risk Perception and Risk Evaluation. After looking at the framework of Disaster Risk Management we will concentrate on the aspect of Risk Governance, with stakeholder involvement as the main issue. We will then see how spatial information can be used in Risk Visualization as part of the Risk Communication process. We will look specifically to the use of WebGIS as a tool in communicating risk information to other stakeholders.

In the second part of the session we will then concentrate on the different structural and non-structural measures for risk reduction. Within that part we will do a simulation exercise where you are considered to be in the geoinformation department of the RiskCity municipality and you have to provide the right information to the emergency managers at the right time. The various risk reduction measure are evaluated and compared using a cost-benefit analysis. You will also do a Riskcity exercise on cost-benefit analysis. The last section deals with the use of risk information in Strategic Environmental Assessment (SEA).

The table below gives an overview of this session:

Section	Topic	Task	Time required		
7.1	Introduction to disaster risk management		Day 1	0.25 h	0.50 h
		Task 7.1: Key risk reduction elements and spatial data		0.25 h	
7.2	Risk perception and risk evaluation			0.25 h	0.50 h
		Task 7.2: Risk perception		0.25 h	
7.3	Risk governance			0.50 h	1.25 h
		Task 7.3: Risk governance		0.75 h	
7.4	Risk communication		Day 2	0.50 h	1.25 h
		Task 7.4: Risk communication		0.75 h	
7.5	Risk visualization			0.50 h	3.75 h
		Task 7.5: Risk visualization		0.75 h	
		Task 7.6: WebGIS exercise		2.00 h	
		Task 7.7: WebGIS and risk		0.50 h	
7.6	Risk reduction measures		Day 3	0.50 h	4.00 h
		Task 7.8: Risk reduction measures		0.50 h	
		Task 7.9: RiskCity exercise on disaster preparedness planning		3.00 h	
7.7	Cost benefit analysis		Day 4	1.00 h	4.00 h
		Task 7.10: riskcity exercise cost-benefit analysis		3.00 h	
7.8	SEA and risk assessment			0.25 h	0.25 h
				Total	**16 h**

7.1 Introduction to disaster risk management.



In this session we will concentrate on how you use risk information. In the last session we have been through the various steps to derive at risk maps. But once the risk maps have been generated, the question is: what for? How can we use these data in disaster risk management. And who will use this data? Which stakeholders require what type of information? How is the information shared? How is it visualized? Which role does it play in risk governance? Which risk level is acceptable? And what are the various risk reduction options? How much will they actually reduce the risk? These are the questions that will be addressed in this chapter. We start this chapter with a section on disaster risk management.

In section 1.2 an introduction was given to disaster risk management. Emphasis was given their also to the United Nations International Strategy for Disaster Reduction (ISDR). The ISDR Framework for Disaster Risk Reduction describes the general context and primary activities of disaster risk management, and elements regarded as necessary for any comprehensive disaster risk reduction strategy (see Figure 7.1). Some of the main points important for the use of spatial disaster risk information are:

- Effective disaster risk management depends on the informed participation of all stakeholders.
- The exchange of information and easily accessible communication practices play key roles.
- Data is crucial for ongoing research, national planning, monitoring hazards and assessing risks. The widespread and consistent availability of current and accurate (geo) data is fundamental to all aspects of disaster risk reduction. (UN-ISDR, 2004)

The ISDR conceptual framework for disaster risk reduction is placed in the broader context of sustainable development, where socio-cultural, environmental, economic and political factors/ goals need to be considered. In order to meet all these goals good governance is needed on all levels, from national to community level.

The UN-ISDR system:

The ISDR system supports nations and communities to implement the Hyogo Framework. ISDR is a system of partnerships including governments, inter-governmental and non-governmental organizations, international financial institutions, scientific and technical bodies and specialized networks as well as civil society and the private sector. The ISDR system's basic structure includes a Global Platform for Disaster Risk Reduction, a Management Oversight Board, an Inter-Agency Group that developed an ISDR System Joint Work-Programme, thematic and regional platforms and the UN/ISDR secretariat Conceptual framework for disaster risk reduction.
See: www.unisdr.org

Governments and communities have a shared responsibility to develop an integrated approach, in the context of sustainable development with the involvement of the different stakeholder groups. From the definitions on Disaster Risk Reduction (DRR) and Disaster Risk Management (DRM) of UN-ISDR (see section 1.2 for these) it is clear that disaster Risk Management is also very much focused on prevention. Studies have shown that for every Euro invested in risk management, broadly 2 to 4 Euros are returned in terms of avoided or reduced disaster impacts on life, property, the economy and the environment.

Despite the obvious benefits, disaster risk management (DRM) measures are often difficult to implement and there is still in many situations a reliance on reactive approaches after the disaster has happened. For example, bilateral and multilateral donors still allocate 90% of their disaster management funds for relief and reconstruction and only the remaining 10% for disaster risk management. One of the International NGO's (Tearfund) active in DRR, carried out a study showing that disaster risk reduction was given a relatively low priority within donors' relief and development plans, processes and practical implementation. Explanations for this low priority included:

- A lack of knowledge and understanding of the nature of risk reduction;
- The cultural divide between 'relief' and 'development' sectors, resulting in risk reduction not being fully 'owned' by either;
- Risk reduction 'competing' with other pressing development needs.
- A lack of concrete evidence regarding the types and extent of the cost and benefits of preventive disaster risk management measures.

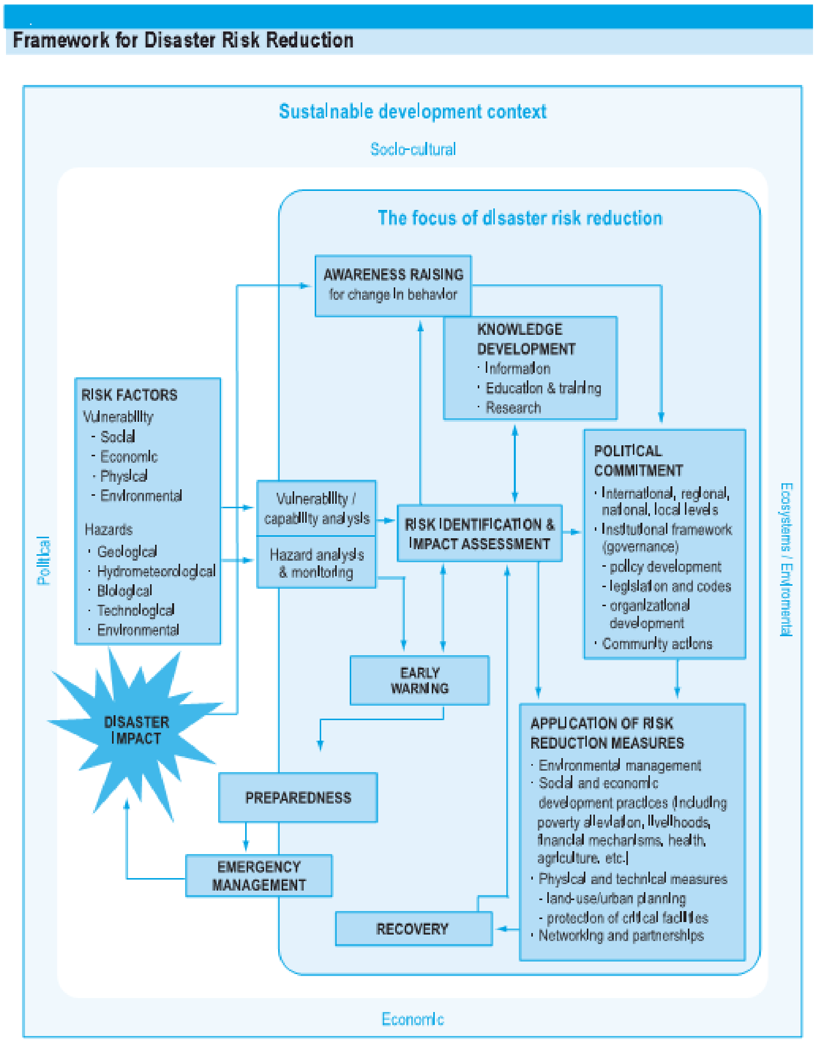


Figure 7.1: Framework for Disaster Risk Reduction(Source: "Living with Risk" (UN 2004))

The ISDR Framework for Disaster Risk Reduction (Figure 7.1) describes the general context and primary activities of disaster risk management, and elements regarded as necessary for any comprehensive disaster risk

The disaster risk reduction framework is composed of the following fields of action, as described in ISDR's publication 2004 "Living with Risk: a global review of disaster reduction initiatives (figure 7.1).

The Framework has the following main components:

Awareness raising to change the behavior in increasing vulnerability;

Knowledge development: information, education and research;

Political commitment and institutional development or **governance**;

Early warning, monitoring and forecasting

Risk management application & instruments : including environmental management, land-use and urban planning, protection of critical facilities, application of science and technology, partnership and networking, and financial instruments; physical and technical measures;

Disaster Preparedness, Contingency planning and emergency management. The risk reduction measures are both structural and non-structural and range from physical and technical planning, land use and urban planning and protection of critical facilities to social and economic development practices including poverty alleviation.

Central in the framework is the **Identification of risk and the impact assessment**. This multi-hazard risk assessment, including the analysis of hazards and the analysis of vulnerability and capacity, is a crucial prerequisite in order to be able to work on the other (above mentioned) building blocks of the Risk Reduction Strategy.

Apart from the UN-ISDR framework for disaster risk reduction many other frameworks have been presented, which often have a lot of common aspects, but have a difference in focus. Another framework we would like to present here, is the one from the Inter-American Development Bank. Table 7.1 lists the key elements of the proposed risk management strategies.

Table 7.1. Key elements for risk management strategies (IADB 2000a, 2004)

Pre-disaster activities				**Post-disaster activities**	
Risk identification	**Mitigation**	**Risk transfer**	**Preparedness**	**Emergency response**	**Rehabilitation-reconstruction**
Hazard assessment (frequency, magnitude, location)	Structural and non-structural works and actions	Insurance, reinsurance of public infrastructure and private assets	Warning systems, communication systems, protocols	Humanitarian assistance	Rehabilitation, reconstruction of damaged critical infrastructure
Vulnerability assessment (population and assets exposed)	Land-use planning and building codes	Financial market instruments (catastrophe bonds, weather-indexed hedge funds)	Contingency planning (utility companies, public services)	Clean-up, temporary repairs and restoration of services	Macroeconomic and budget management (stabilization, protection of social expenditures)
Risk assessment (function of hazards and vulnerability)	Financial incentives for preventive behavior	Public services with safety regulations (e.g. energy, water, transportation)	Networks of emergency responders (local, national)	Damage assessment and identification of priorities for recovery	Revitalization of affected sectors (e.g. exports, tourism, agriculture)
Hazard monitoring and forecasting (space-time modeling, scenario building)	Education, training and awareness about risks and prevention	Financial protection strategies	Shelter facilities, evacuation plans	Mobilization of recovery resources (public-multilateral, insurance)	Incorporation of risk management in reconstruction processes

Figure 7.3 shows the structure that will be followed in this chapter, and which focuses more on the use of (spatial) risk information, which is also the focus of this book.

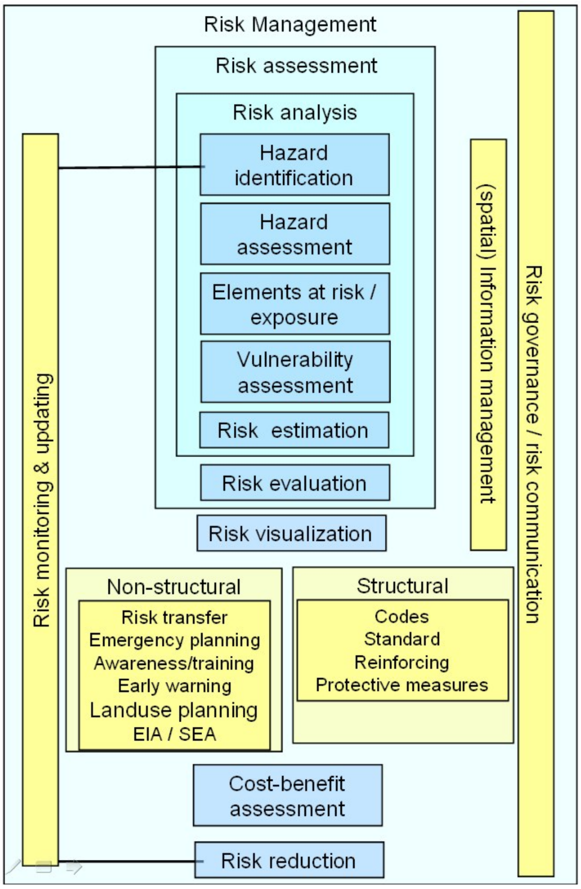


Figure 7.2: Framework on Risk Management, with indication of the various

Table 7.1 Definitions for risk management (IUGS, 1997).

Term	**Definition**
Risk analysis	the use of available information to estimate the risk to individuals or populations, property, or the environment, from hazards. Risk analysis generally contains the following steps: hazard identification, hazard assessment, elements at risk/exposure analysis, vulnerability assessment and risk estimation.
Risk evaluation	the stage at which values and judgements enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental, and economic consequences, in order to identify a range of alternatives for managing the risks.
Risk assessment	the process of risk analysis and risks evaluation
Risk control or risk treatment	the process of decision making for managing risks, and the implementation, or enforcement of risk mitigation measures and the re-evaluation of its effectiveness from time to time, using the results of risk assessment as one input.
Risk management	the complete process of risk assessment and risk control (or risk treatment).

The process of risk estimation and risk analysis has been extensively treated in the previous sessions. Therefore no further emphasis will be given to that here. The process of risk assessment goes beyond the process of risk analysis and also looks if the outcome of the risk estimation is acceptable to the society or community given the existing economic, social, political, cultural, technical and environmental conditions. If the risk level is not acceptable, risk reduction measures have to be taken, which can be either structural measures or non-structural measures.

Task 7.1: Key risk reduction elements and spatial data (duration 15 minutes)

When you look at table 7.1 and the different activities required in the various pre- and post disaster phases; for which activities is the use of spatial data essential? Indicate the phases where spatial data is crucial and the ones for which it is of secondary importance.

Disaster risk management is the systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural and related environmental and technological disasters.

Traditionally the process of Disaster Risk Management was presented as a cycle, in which the various phases would follow each other until the next disaster event would happen. It involves several phases: Prevention, Preparedness, Relief / Response, Recovery and Reconstruction. This cyclic way of presenting Disaster Risk Management has been debated. Others mentioned that all phases receive more or less attention depending on the situation. In a disaster event obviously relief and response would get more attention, and later on prevention would become more dominant (Expand-Contract Model). However, in our opinion the ideal way of representing Disaster Risk Management is in the form of a circle that becomes larger each time due to improvements in the process. Small hazard event will not turn into disaster events, and don't need to be followed-up with relief/response. It takes more time before a larger hazardous event still would become a disaster event, and relief response would be needed. Eventually the aim is to break the circle. Due to good performance of the pre-disaster phases, a hazard event doesn't turn into a disaster event anymore. Of course there will always be hazard events, like earthquakes or floods, but the losses and damage of these would be reduced each time more. The various phases are explained below. Disaster prevention includes:

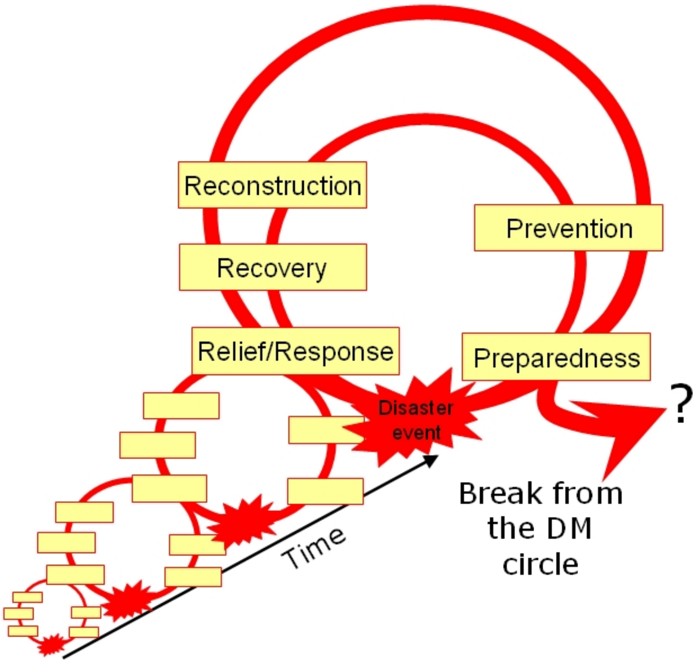


Figure 7.3: Traditional view of the disaster management cycle, and the view of the cycle as an expanding one with increasing success of disaster risk management until it will not lead to a new disaster event.

- Risk analysis, risk evaluation and effective risk reduction.
- The formulation and implementation of long-range policies and programmes to prevent or eliminate the occurrence of disasters or more frequently, to reduce the severe effects of disasters (mitigation strategies);
- Establishment of legislation and regulatory measures, principally in the field of physical and urban planning, public works and

Prevention:
Activities to provide outright avoidance of the adverse impact of hazards and means to minimize related environmental, technological and biological disasters.
Depending on social and technical feasibility and cost/benefit considerations, investing in preventive measures is justified in areas frequently affected by disasters. In the context of public awareness and education, related to disaster risk reduction changing attitudes and behavior contribute to promoting a "culture of prevention".

building e.g. rules on land use planning, rules on building codes, building of special constructions, etc.

In essence, disaster prevention consists of the acquisition of basic geographically-registered information on hazards, the vulnerability of the elements at risk and consequent risks analysis and, on the basis of that information, the planning of human activities such as land-use, construction and public/engineering works so as to reduce or eliminate the possibility of damage and destruction.

Preparedness is supported by the necessary legislation and means a readiness to cope with disasters or similar emergencies which cannot be avoided. It includes:

- forecasting and warning / monitoring
- education and training of the population
- organization for and management of disasters situations,
- preparation of operational plans, training of relief groups,
- stock piling of supplies
- earmarking of necessary funds

Preparedness:
Activities and measures taken in advance to ensure effective response to the impact of hazards, including the issuance of timely and effective early warnings and the temporary evacuation of people and property from threatened locations (UN-ISDR, 2004).

As distinct from disaster prevention, which seeks to mitigate the severity of, or to totally avoid, disasters, preparedness presumes the inevitability of some disasters and prepares for the actions required when they occur. Major components of disaster preparedness are: organization, emergency operations, communications, evacuations, disaster warnings.

The concept of "mitigation" spans the broad spectrum of disaster prevention and preparedness activities. Mitigation is a management strategy that balances current actions and expenditures with potential losses from future hazard occurrences. It means reducing the actual or probable effects of an extreme hazard on man and his environment. Perhaps the most fundamental point to be made about a disaster is that the situation - both in reality as well as perception - changes with time and, especially with a fast-breaking disaster, it is necessary to maintain awareness of current status. In many emergencies the first aid comes from the family or neighbours, then the community, then perhaps provincial or regional sources, and only after that, is aid received from national and international sources.

Relief / Response:
The provision of assistance or intervention during or immediately after a disaster to meet the life preservation and basic subsistence needs of those people affected. It can be of an immediate, short term, or protracted duration.

The effective delivery of relief from the community level upwards, depends strongly on the adequacy of public awareness and disaster preparedness plans and the effectiveness with which they are carried out. Major components of disaster relief are: assessment of the situation (both the assessment of the extent of the damage as well as that of relief requirements), rescue operation, relief supplies and handling of strategic problems.

Recovery / Reconstruction:
Decisions and actions taken after a disaster with a view to restoring or improving the pre-disaster living conditions of the stricken community, while encouraging and facilitating necessary adjustments to reduce disaster risk.

After the relief phase recovery activities start until all systems return to acceptable, normal or better levels.

- Short term recovery activities return vital life-support systems to minimize operation standards;
- Long term recovery activities may continue for years until acceptable performance levels are achieved.

Recovery (rehabilitation and reconstruction) affords an opportunity to develop and apply disaster risk reduction measures (UN-ISDR, 2004).

7.2 Risk perception and risk evaluation

Risk can be divided into two distinct dimensions:

- The "factual" dimension, which indicates the actual measured level of risk, and which can be expressed in probability of losses (e.g. number of people, building, monetary values)
- The "socio-cultural" dimension, which includes how a particular risk is viewed when values and emotions come into play.

Risk evaluation is a component of risk assessment in which judgments are made about the significance and acceptability of risk. This can be for society as a whole or for certain groups or individuals. Risk evaluation is done by comparing the level of risk against predetermined standards, target risk levels or other criteria

Risk evaluation is the stage at which values and judgment enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental, and economic consequences, in order to identify a range of alternatives for managing the risks.

Risk perception is about how individuals, communities, or governments perceive/judge/evaluate/rank the level of risk, in relation to:

- **Their personal situation.** For instance a teenager would perceive the risk of hang gliding much lower than a middle aged person.
- **Cultural and religious background**: the cultural background plays an important role, as it will define the way in which people see hazardous events as "Act of God", or not.
- **Social background**: people living in squatter areas may perceive the same objective level of risk as being much lower than people living in more developed areas.
- **Economic level**: the lower the economic background, generally the lower the perception of the risk to (natural) events will be, as it is rated against other socio-economic problems.
- **Political background**: the political background of people also plays an important role. For instance in countries with a centralistic political system, the risk is perceived as a risk that the government should deal with more easily than in a country where individual actions and decisions are rated more important.
- **Level of awareness**: in order to perceive risk it is necessary that people are aware of the risk. Therefore the awareness level is very important.
- **Media exposure**: related to that is the media exposure. If a particular threat is getting a lot of media exposure, the risk is also perceived higher.
- **Other risks**: when perceiving risks people will always relate risk to each other. Risk that are related to more frequently occurring events, for instance flooding, generally are perceived as more problematic then risk from very infrequent events such as earthquakes.
- **Risk reduction situation**: a person living in a country where much emphasis is given to risk reduction will perceive

Risk perception is analyzed by interviewing people and asking them to rank the dangers they foresee in their own situation, or ask them to indicate the way in which they worry about certain aspects.

Figure 7.4: Risk perception.

Task 7.2: Risk perception (duration 15 minutes)
Suppose you would have to make interviews of people living in flood prone areas in:
***A**. The parts of the Netherlands that are below sea level, which are protected by dikes. In the Netherlands all flood control is the task of the local authorities (waterboards) and central government.*
***B**. In the squatter areas of RiskCity that have experienced a massive flood event in 1998. After the flood event many people came from the rural parts of the country and settled in the flood prone areas.*
***C**. In a city on an alluvial fan downstream of a mountainous area, where there is a possibility that a future earthquake would trigger landslides damming a river and causing a lake-break out flood.*

- *Which questions would you ask them?*
- *What do you think would be the outcomes in the different cases?*

In the risk evaluation a number of key aspects play a role (see table 7.3).

Table 7.3 Factors that affect the level of acceptability of risk. Partly from: Sandman, P. M. 1993. Responding to community outrage: Strategies for effective risk communication

Factor	Explanation
Unfamiliarity	When people are familiar with risk involved in an activity they are more willing to accept it. Societies experiencing frequent landslides may have different level of landslide risk acceptance that that experiencing rare landslide situations.
Involuntary	Voluntary risks are risk for which one can choose to take them (e.g. driving a motorcycle), whereas involuntary risks are those for which one cannot choose, but is exposed to. People are more obviously willing to accept voluntary risks (as it is their own choice) rather than involuntary risks (e.g. the construction of a hazardous chemical industry nearby your house)
Incontrollable	The inability to control a risk decreases its acceptability. Once the risk is under personal control (e.g. driving a car) it is more acceptable than the risk controlled by other parties (e.g. travelling as a passenger).
Dreaded	A risk that is highly feared (e.g. airplane crash) is considered less acceptable than one that is not (e.g. car accident)
Memorable	A risk that is embedded in a remarkable event (e.g. Indian ocean tsunami) is judged as being less acceptable.
Catastrophic	An event that is catastrophic is judged less accepted than many small events having the same impact
Uninformed	Risk of which people are not properly informed are judge to be more acceptable
Long term	Long term risk, with a small probability of occurrence or that impact over a larger period of time are judge to be more acceptable than short term ones.
Unbeneficial	Risk that do not have any additional benefits are judged to be less acceptable than those that do have added benefits
Untrustworthy	If the source of the risk or method of analysis is not trustworthy, the risk will be judged to be less acceptable
Uncertain	A risk that is very uncertain and where we know little about is judged to be less acceptable.

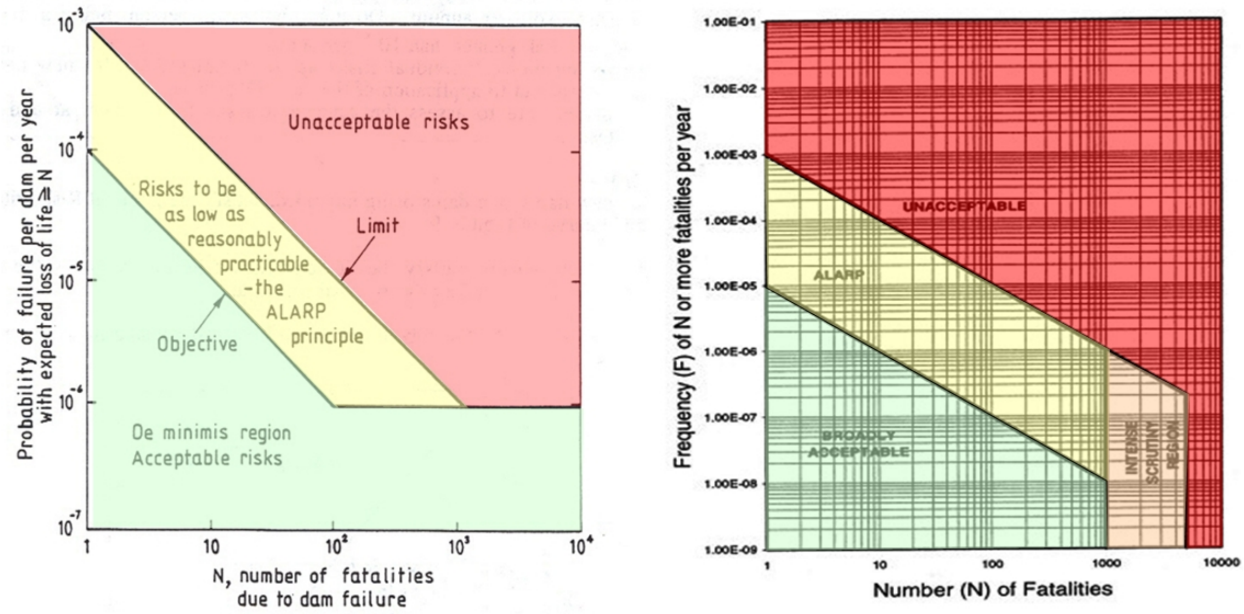
These aspects define the levels at which risk is considered to be acceptable or not acceptable.

Acceptable risk: a risk which the society or impacted individuals are prepared to accept. Actions to further reduce such risk are usually not required unless reasonably practicable measures are available at low cost in terms of money, time and effort.
Tolerable risk: a risk within a range that society can live with so as to secure certain net benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if possible.
ALARP (As Low As Reasonably Practicable) principle: Principle which states that risks, lower than the limit of tolerability, are tolerable only if risk reduction is impracticable or if its cost is grossly in disproportion (depending on the level of risk) to the improvement gained.

Figure 7.5: Risk perception?

Risk acceptability is mostly done on the basis of F-N curves (see also section 6.2.1). F-N curves display the probability per year of causing N or more fatalities (F) to N. Such curves may be used to express societal risk criteria and to describe the safety levels of particular facilities. Generally the incremental risk from a hazard to an individual should not be greater than the level to which someone is already exposed to in everyday life. This defines therefore the starting line with N=1.

Figure 7.6: Use of F-N curves to define risk acceptability criteria. Left: the general principle of dividing the F-N curve into regions of acceptable, ALARP (tolerable), and unacceptable risk levels. Right: example of risk acceptability levels for Hongkong.

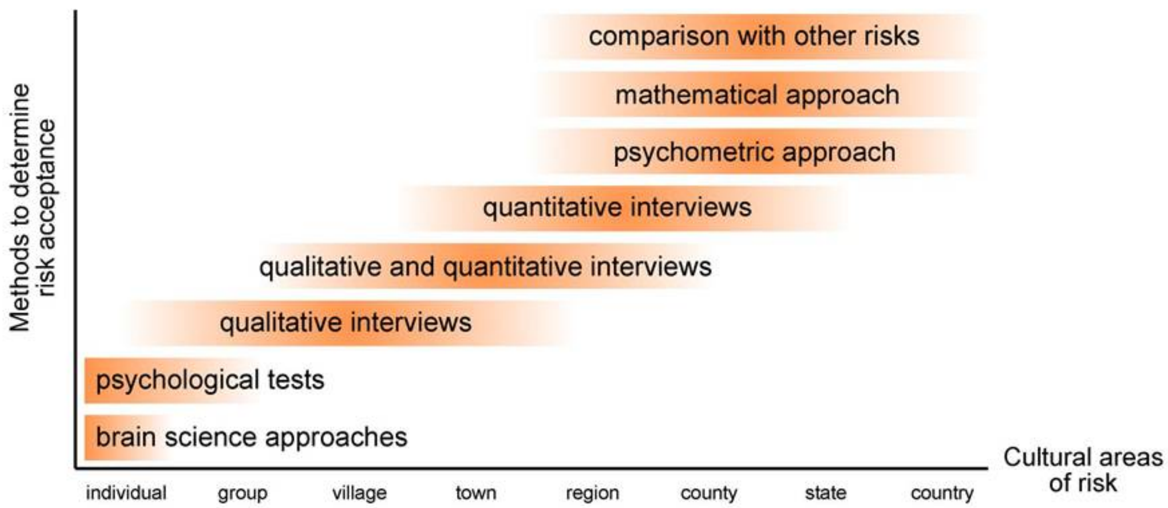


The definition of acceptability levels is a responsibility of the national or local government in a country. Risk acceptability depends on many factors, and differs from country to country. Therefore it is also not possible to simply export them to other countries. Figure 7.7 shows a series of methods that can be used to define acceptability levels. Table 7.4 shows some examples of individual acceptable risk thresholds from different countries and the box on the next page gives an example of societal risk thresholds for the Netherlands.

Table 7.4: Examples of individual acceptable risk thresholds for natural hazards in different countries.

	Individual acceptable risk level
UK Health and Safety Executive Board	< 10-4 /year
Iceland, Ministry for the Environment	> 3 x 10-4 / year
Switserland (BUWAL, Swiss agency for the Environment, Forests and Landscape)	< 0.3x10-4 / year
Hongkong (Geotechnical Engineering Office)	Existing developments: <10 –4 / year New developments: <10-5 /year
Netherlands	< 1.4 × 10-5/year

Figure 7.7: Methods that can be used to define risk acceptability levels, depending on the level of analysis.



Example: Acceptable risk levels in the Netherlands.

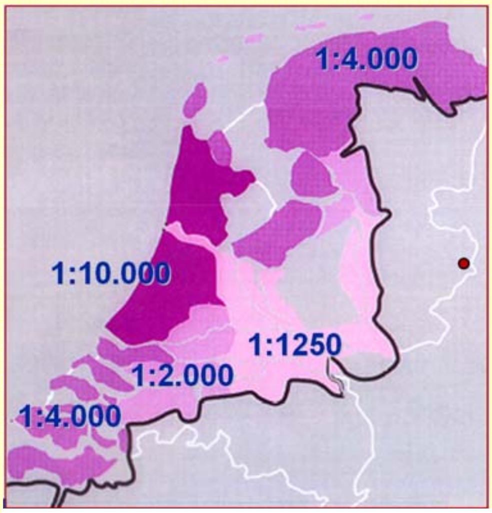


Figure 7.8: Safety standards with respect to flooding in the Netherlands

The Netherlands is a country subjected to severe risk to flooding, both from the sea as well as from the main rivers (Rhine, Meuse). The country has been severely affected by flooding in many occasions. In fact flooding has been intricately connected to the development of the Netherlands. The last major flood disaster happened in 1953, when of the southwestern part of the Netherlands was flooded due to a severe northwestern storm and over 1800 people lost their lives. To protect the country from flooding, so-called “dyke rings” have been constructed, which protect the low lying areas that they surround. A National Commission has set the acceptable risk for complete failure of every "dyke ring" in the country at 1 in 125,000 years. However the cost of building this level of protection was deemed too high, so the acceptable risk was set according to region as follows:

- North and South Holland (the area with the highest concentration of population) 1 per 10,000 years
- Rest of the country at risk from sea flooding 1 per 4,000 years
- Transition areas between high land and low land 1 per 2,000 years

River flooding causes less damage than salt water flooding so areas at risk from river flooding have a higher acceptable risk. Also river flooding has a longer warning time, making for a lower estimated death toll.

- South Holland at risk from river flooding 1 per 1,250 years
- Rest of the country at risk from river flooding 1 per 250 years.

These acceptable risks were put down in the Delta law, requiring government to keep risks of catastrophic flooding within these limits and upgrade defenses should new insights into risks require this.

The current Dutch policy on risk acceptance looks at two levels of risk: Individual and societal risk. The individual risk for a point location around a hazardous activity is defined as the probability that an average unprotected person (hypothetically) permanently present at that point location, would get killed due to an accident at the hazardous activity. The individual risk depends on the geographic location and is represented as lines with equal amount of risk (iso-risk lines). The societal risk for a hazardous activity is defined as the probability that a group of more than N persons would get killed due to an accident at the hazardous activity area. The societal risk limit is set at $F=10^{-3}/N^2$, which serves as a guideline (F = annual frequency, N = number of fatalities)

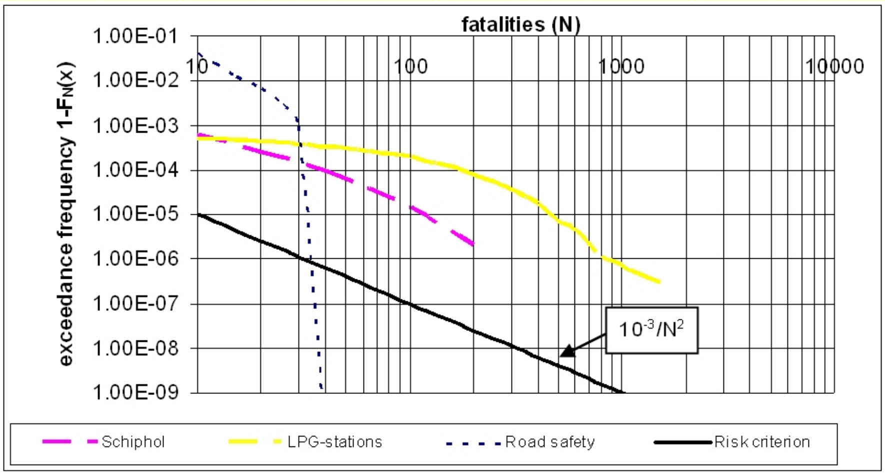


Figure 7.9: FN-curves with the national risk acceptability criterion (adapted from: National Institute for Public Health and the Environment, 2004, and Vrijling, van Gelder and Ouwerkerk (2008))

7.3 Risk Governance.

In the last decades the word governance has become very popular, and is being used in many different settings, including the risk management field.

The term "governance" refers to the capacity of actors, social groups and institutions to build an **organizational consensus**, to agree on the contribution of each partner and on a common vision. Governance describes structures and processes for collective decision making involving governmental and non-governmental actors.
Risk governance includes the totality of actors, rules, conventions, processes, and mechanisms concerned with how relevant risk information is collected, analysed and communicated and management decisions are taken (IRGC)

Risk management cannot take place without proper risk governance. Risk governance has been integrated in the ISDR, Hyogo framework for action: "Promote and improve dialogue and cooperation among scientific communities and practitioners working on disaster risk reduction, and encourage partnerships among stakeholders, including those working on the socio-economic dimensions of disaster risk reduction".
Governance depends on the level of political commitment (on international, national, regional and local levels) and strong institutions. Good governance is identified in the ISDR Framework for disaster reduction as a key area for the success of effective and sustained disaster risk reduction. Good governance will:

- Elevate disaster risk reduction as a policy priority;
- Allocate the necessary resources for disaster risk reduction;
- Enforce implementation of disaster risk reduction measures and assign accountability for failures; and
- Facilitate participation from civil private society.

The major components for successful governance for disaster risk reduction are (table 7.4)

- Policy and planning;
- Legal and regulatory frameworks;
- Resources;
- Organisation and structures.

Governance: the institutional and policy framework for disaster risk reduction
http://www.preventionweb.net/files/4080_governacedevelopment.pdf

Governance has different dimensions:

- **Economic governance** includes the decision-making processes that affect a country's economic activities and its relationship with other economies. This has major implications for equity, poverty and quality of life.
- **Political governance** is the process of decision making to formulate policies, including national disaster reduction and planning. The nature of this process and the way it brings together the state, non-state and private sector actors determines the quality of the policy outcomes.
- **Administrative governance** is the system of policy implementation and requires the existence of well-functioning organizations at the central and local levels. In the case of disaster risk reduction, it requires functioning enforcement of building codes, land-use planning, environmental risk and human vulnerability monitoring and safety standards.

Policy can be enacted at a variety of levels and in a number of different ways, exerting different degrees of control varying from very binding legislation to vague guidelines and incentives for certain practices to be adopted. Three policy mechanisms can be identified:

- Direct (legal) regulation,
- Economic incentives
- Moral persuasion.

The national context generally provides the overall framework in which general aims of the policy are identified and the instruments of implementation are articulated. Some fulfilment of the policies is overseen by government ministries but many of the policies are actually carried out by other government agencies and by local authorities.

The International Risk Governance Council (IRGC) developed a framework for risk governance integrating scientific-, economic-, social- and cultural aspects and includes the effective engagement of stakeholders (see figure 7.3.). It relates Pre-Assesment conditions, Risk Appraisal, Tolerability & Acceptability Judgement of Risk and Management of Risk. There are two different spheres:

- The technical sphere focusing on the generation of knowledge and information on risk;
- The management sphere, focusing on decision making and implementation of actions.

The risk process has 'communication' as a companion to all phases of addressing and handling risk and is itself of a cyclical nature. However, the clear sequence of phases and steps offered by this process is primarily a logical and functional one and will not always correspond to reality (IRGC).

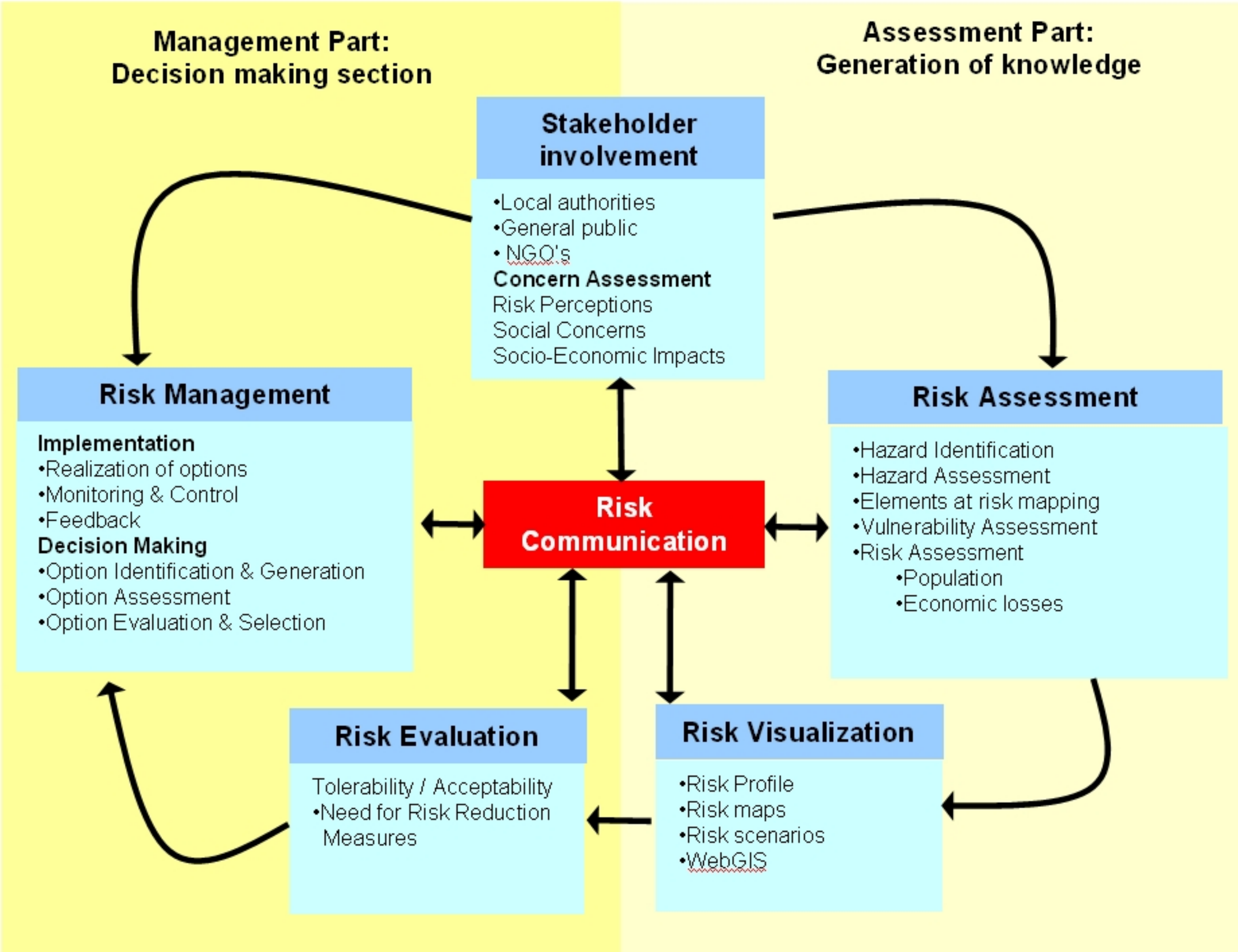


Figure 7.10: The International Risk Governance Council Risk Governance Framework (modified fromr IRGC, 2006)

Task 7.3: Risk Governance (duration 45 minutes)
Download the document:
Introduction to the IGRC Risk Governance Framework, from the following website:
http://www.irgc.org/IMG/pdf/An_introduction_to_the_IRGC_Risk_Governance_Framework.pdf

Read the document. What are your main findings after reading the document?

The aim of Risk governance is to involve the various stakeholders within all aspects of risk management. The involvement of local people is in the process is a very important component. There are many aspects that are relevant for stakeholder involvement in the process of risk governance. Table 7.5 gives a list of the main aspects together with the main questions related to them.

Table 7.5: Important aspects in stakeholder involvement (source: Glade, 2008)

Aspect	**Question**
Identification	Are stakeholders identified (through a proper process - including prioritisation)?
Representation	Are all relevant social groups represented?
Engagement	Are all relevant social groups motivated to engagement?
Access to Information	Share of stakeholders that regularly take part in information meetings
Interest	Are the stakeholders interested in having information, in the outcome?
Trust	Do the stakeholders trust the decision makers, institutions and information available?
Acceptance - Process	Do the stakeholders accept the process?
Acceptance - Outcome	Do the stakeholders accept the outcome?
Dialogue	Are stakeholders engaged in dialogue with listening and mutual understanding?
Financial	Do the financial resources available meet the needs of the governance process defined?
Personnel	Do the personnel resources available in expertise and capacity meet the needs of the governance process defined?
Time	Is there calendar time to meet the governance process defined?

There are many stakeholders involved in the risk management framework. The most important ones are the general public, decision makers and technical staff. However, there are many more, each with its own role. Table 7.6 gives an overview of stakeholders with their interests.

Table 7.6: Overview of stakeholders in risk management and their main interests

Interested in risk information	Stakeholder	Main interests
Limited	Political representatives	Get (re)elected, and earn the favor of the public
	Business sectors	Making profits, with less restrictions as possible
	General public	Live safely where they want without restrictions
	Decision makers of (local) authorities	Taking decisions on optimal development of the area under their jurisdiction and optimizing safety of the population.
	Technical staff of local authorities	Carry out regulations without problems
	Media	Discover and present remarkable/shocking information
	NGO's	Promote environmental and sustainable development
	Pressure groups	Bring their point of view under the attention of the media and influence public opinion
	Disaster management authorities	Make adequate disaster preparedness measures
	Insurance industry	Make optimal insurance policy for making profits
Very much	Scientific / technical staff of professional organizations	Collect and present realistic information on hazards and risks, and get enough funds from national government for their work.

The information presented in table 7.6 is a generalization. In reality these stakeholders might have quite a different range of interests, in particular the political representatives, the general public and the decision makers of (local) authorities. Once they become sufficiently aware of the risk situation their main interests might change quite drastically, from a "don't want to know" position, to a very active position, in which for example the public will be closely related to political pressure groups. Quite often the interests of stakeholders are different, even opposite, which makes the stakeholder communication a very important component in the risk governance framework.

7.4 Risk Communication

One of the most essential parts of risk governance is risk communication.

Risk communication is the interactive exchange of information about risks among risk assessors, managers, news media, interested groups and the general public.

Risk communication focusing on the imminent threat of an extreme event is referred to as a warning and is meant to produce an appropriate emergency response. On the other hand a risk communication program can also focus on the long-term potential for such events to happen, and is then called a hazard awareness program, intended to produce long-term hazard adjustments.
Communication should be analyzed in terms of **who** (Source) says **what** (Message), via **what medium** (Channel), to **whom** (Receiver), and directed at what kind of **change** (Effect). One of the models used of the factors that influence individual's adoption of protective actions against natural and technological hazards and disasters is called the Protective Action Decision Model (PADM) (See figure 7.11).

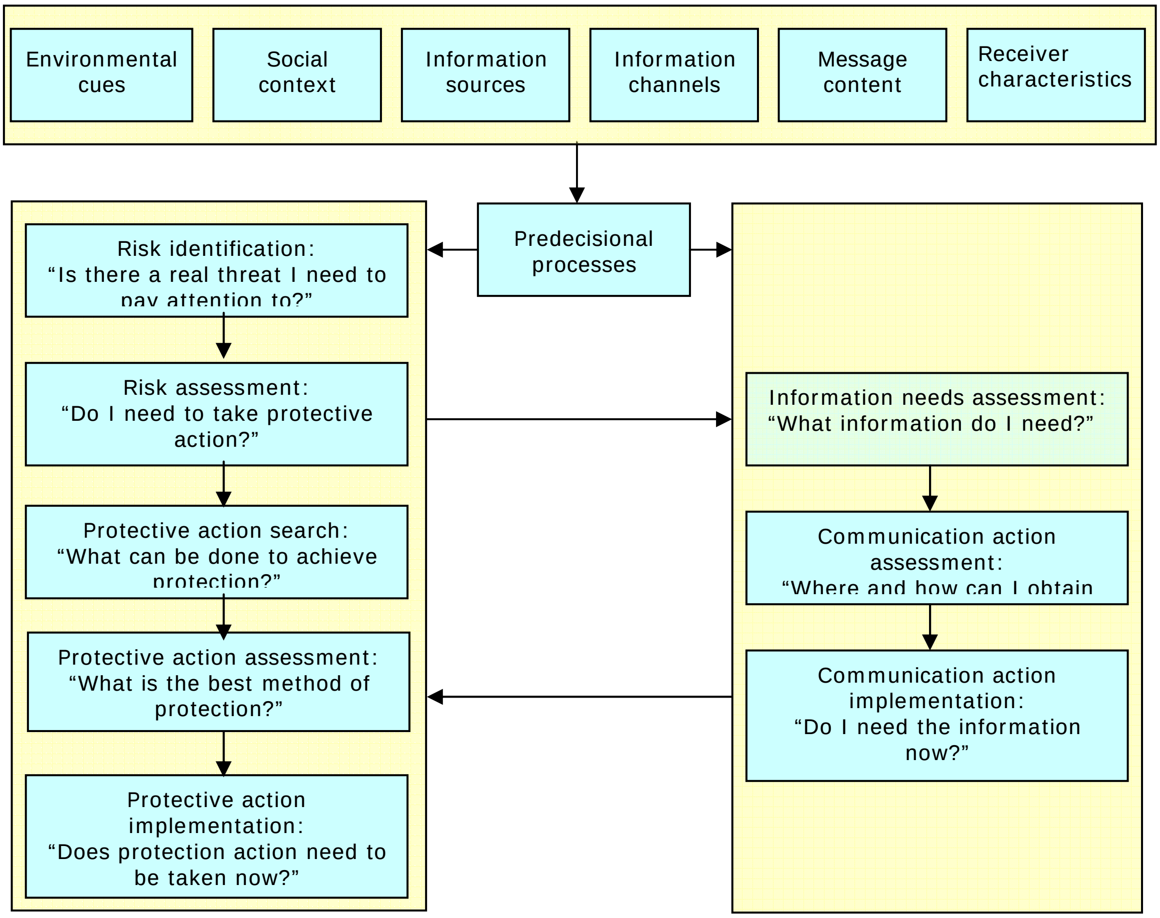


Figure 7.11: The PADM model for risk communication (Source: Lindell and Perry, 2004)

The process of decision making begins with environmental cues or risk communication messages that initiate a series of predecisional processes. In turn, these predecisional processes stimulate either a protective action decision making process or an information seeking process. To proceed through the successive stages of either process, the individual must arrive at an affirmative answer to the questions posed. The dominant tendency is for environmental cues and risk communication messages to prompt protective action decisionmaking, but information seeking occurs when there is uncertainty about the answer to the critical question at a given stage in the protective action decisionmaking process. Once the question is resolved, processing proceeds to the next stage in the protective action decisionmaking process.

Risk communication can be done in a variety of manners and at different levels. The main differentiation is between risk communication at the national level, using mass media campaigns, and risk communication at the local level, where more focused measures can be used.
Risk communication at the national level is aimed at:

- making people aware of the risk in their neighborhood,
- improving their knowledge on possible disasters and how they could be prepared,'
- changing their attitude towards disaster preparation, and
- changing eventually their behavior.

National authorities can make use of a variety of tools to communicate the risk to the population. In these cases the information is normally not site specific and is directed to all people in the country.

- **Mass media**: television, radio, newspaper; this is the standard way of communicating to large audiences. Several countries have launched national campaigns to increase the awareness of the general public to disasters and make them prepared. These campaigns are not always equally successful. For instance, the disaster prevention campaign in the Netherlands up to some years ago focused on the the following rules: when a disaster strikes, go indoors, close the doors and windows and switch on the radio or tv. Later on the government changed the campaign, and focused on a variety of disaster types, each with a different way to react. Figure 7.12 shows a photograph of the media campaign, and figure 7.13 shows the communication leaflet distributed to the public. Through a website the public is able to get a personalized leaflet with the hazard relevant for the postal code in which they live. Innovative ways have been used to communicate disaster awareness, for instance using movies or soaps with disaster related issues. An example of this is the tv-soap broadcasted on Sri-Lankan national tv dealing with a crisis situation for landslides.

Figure 7.12: Example of the Netherlands media campaign "Think Ahead", which stressed that a disaster cannot be planned.

- **Electronic media**: website, email, email discussion lists, electronic conferencing, distance learning platform, SMS and MMS. Nowadays there many possibilities to use new media for risk communication, for instance the use of SMS messages to people located in an area that is likely to be affected by a disaster. Also for instance the use of twitter (http://twitter.com/) is a new approach to send very short messages
- **Audio-visual**: video, audio, multi-media, artwork, photographs, slide show, model, map.
- **Postal:** direct mailing.
- **Stand-alone print**: billboard, poster, banner, warning sign, flood water level. For instance one of the best ways of promoting earthquake safe constructions in the Kathmandu valley was to support advertisements of a local steel company in defining that by using their iron bars the houses would become earthquake safe.

At a local level the risk communication can be much more focused on the stakeholders involved in a risk assessment, and can consists of :

- **Face-to-face**: meeting, seminar, workshop, conference, march, exhibition, demonstration, training, exchange visit, planning.
- **Distributor print**: leaflet, pamphlet, brochure, booklet, guideline, case study, newsletter, journal, research paper, report.
- **Folk media**: story, drama, dance, song, puppet, music, street entertainment.
- **People**: community leader, volunteer, project worker, head of women's group.

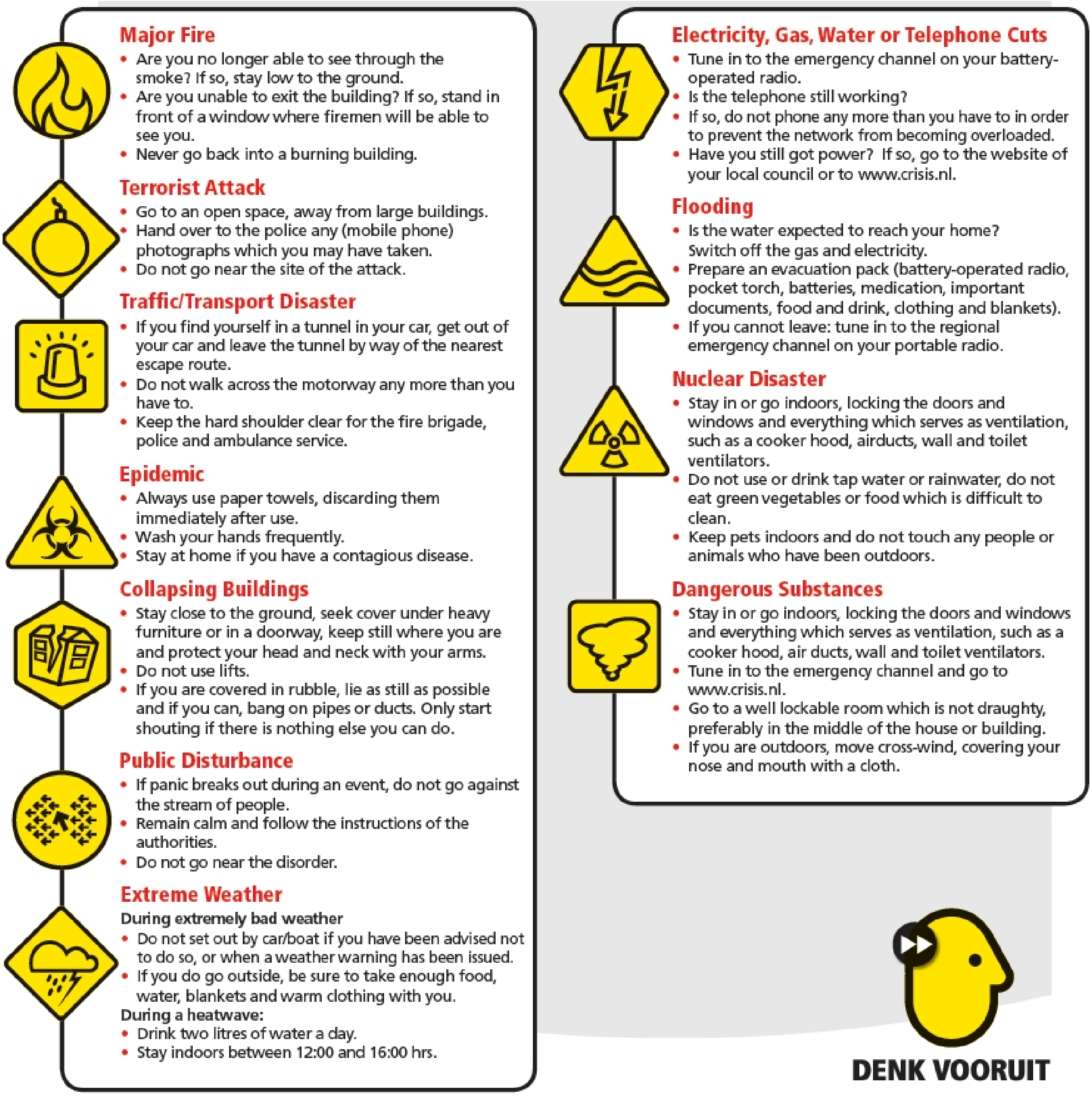


Figure 7.13: Example of the risk communication leaflet used by the Netherlands government (see also : http://denkvooruit.nl/english/).

Task 7.4: Risk Communication (duration 45 minutes)

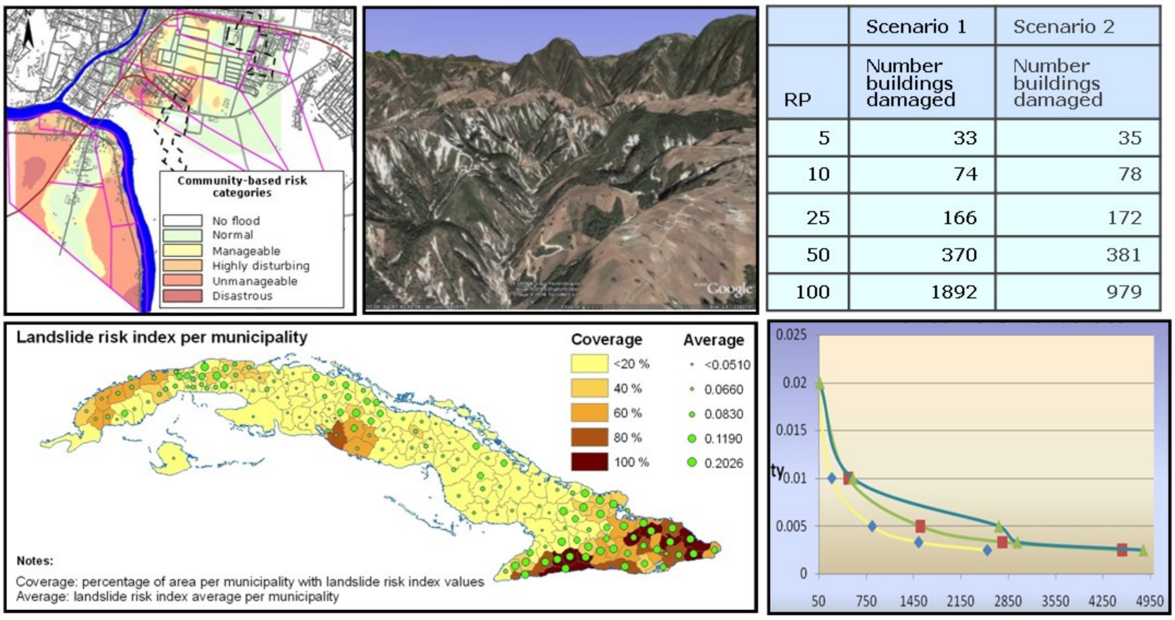
Have a look at the “failed” Netherlands campaign “Think Ahead” on the following site:
http://www.youtube.com/watch?v=EQInZRK8Tbs&feature=related
Why do you think this campaign was not successful?
Check some of the disaster preparedness videos from the US on disaster preparedness:
http://www.youtube.com/watch?v=M1uM9LY80LU&feature=PlayList&p=9D2D73485E97A3AB&playnext=1&playnext_from=PL&index=22
Earthquake drill at school:
http://www.youtube.com/watch?v=bAHNhtRT50A&feature=related
Evacuation planning:
http://www.youtube.com/watch?v=CcRWwcu0O6Y&feature=related
And if you want to see how they thought of informing the public in the seventies in a “moviestyle” manner , watch:
http://www.youtube.com/watch?v=mlcswmcDmCs&feature=related

7.4 Risk visualization

One of the important processes in risk governance is the visualization of risk. Since risk is a spatially varying phenomenon, Geographic Information Systems (GIS) technology is now the standard tool for the production and presentation of risk information as we have seen in the previous sessions. Risk can be presented in the form of:

- **Statistical information per administrative unit** (country, province, municipality, or neighborhood), such as:
    - A Risk Index value resulting from qualitative risk assessment (e.g. Spatial Multi Criteria Evaluation);
    - The Probable Maximum Loss (PML) or Average Annual Loss (See table 6.2);
- **Risk curves**, such as:
    - Loss Exceedance curve for economic risk, or;
    - F-N curves for societal population risk;
- **Maps** which shows the spatial variation of risk over an area:
    - A hazard map with an overlay of the elements at risk;
    - Qualitative classification of risk classes in high, moderate and low;
    - Quantitative estimations of building-, economic or population losses per unit;
- **WebGIS applications** that allow the user to combine different types of information, and display information such as:
    - Hazard maps of individual hazard types;
    - Elements at risk information;
    - Maps of individual risk types, for instance for different return periods;
    - Multi-hazard risk;
- **Spatial Data Infrastructure / Clearinghouses**, where through internet basic GIS data can be shared among different technical and scientific organizations involved in hazard and risk assessment.
- **Animations** showing the spatial and temporal distribution of hazards and risk, such as:
    - Flood animations showing the development of a flood over time, where the flood height, and water velocity are shown per time step as a movie file, overlain with elements at risk information;
    - Fly-throughs, three dimensional displays of risk information over a high resolution satellite image. For instance, Google Earth now offers great opportunities to make such animations, as one can export the risk maps from GIS and KML files that can be directly overlain in Google Earth.

The type of Risk visualization depends very much on the stakeholder to which the risk information is presented. Table 7.7 gives and overview of the relation between stakeholders and the type of risk visualization.



	Scenario 1	Scenario 2
RP	Number buildings damaged	Number buildings damaged
5	33	35
10	74	78
25	166	172
50	370	381
100	1892	979

Figure 7.14: Examples of visualization techniques that can be used for communicating risk information. Above: Maps, 3-D animations and statistical information; below: per administrative unit and loss exceedance curve.

Table 7.7: Relationship between stakeholders in risk management and risk visualization options.

Stakeholder	**Purpose**	**Type of risk visualization**
General public	General information on risks over large areas	Basic WebGIS applications in which they can overlay the location of major hazard types with high resolution imagery or topographic maps.
	Awareness raising	Animations (what if scenarios)
	Community-based DRR projects	Simple maps of the neighborhood with risk class, buildings and other features
Businesses	Investment policies, and location planning	General information about hazards and risks in both graphical and map format.
Technical staff of (local) authorities	Land use regulation / zoning	Map with simple legend in three classes: construction restricted, construction allowed, further investigation required.
	Building codes	Maps indicating the types of building allowed (building type, number of floors)
	Spatial planning	Hazard maps, with simple legends related to probabilities and possible consequences
	Environmental Impact Assessment	Maps and possible loss figures for future scenarios
	Disaster preparedness	Real time simple and concise Web-based information in both map and graphical forms
Decision makers / local authorities	Decision making on risk reduction measures	Statistical information, loss exceedance curves, F-N curves, maps.
	Investments	Economic losses, projected economic losses for future scenarios.
	Strategic Environmental Assessment	General statistical information for administrative units.
NGO's	Influence political decisions in favor of environment and sustainable development	This can vary from simple maps to Web-based applications, depending on the objectives of the NGO
Scientists / technical staff of hazard data producers	Hazard information exchange to public and other agencies	WebGIS applications where they can access the basic information
	Exchange of basic information for hazard and risk assessment	Spatial Data Infrastructure / Clearinghouse for exchanging information
Insurance industry	Development of insurance policy	Loss Exceedance Curves of economic losses, F-N curves
Media	Risk communication to public,	Animations of hazard phenomena that clearly illustrate the problems.

As there are no international standards for risk mapping yet, risk visualization needs to receive more attention and needs to be focused on the stakeholder or end user. A risk assessment is done by a group of thematic experts. The risk map is produced based on the interpretation and cartographic skills of these experts. However, the risk evaluation is carried out by stakeholders (mentioned above) also with their interpretation and cartographic knowledge. If either the researchers, as risk information providers; or the stakeholders, as risk information receivers; perform erroneously, the risk reduction actions taken in the study area may have mistakes, which may lead to serious consequences.

Cartographic aspects of spatial risk information

The fact that risk maps represent 'areas at risk' is the main reason why most maps employ intensity scales in classes for one colour or traffic-light colours, in continuous ramps or in coloured patterns. The proper definition and representation of risk classes is an important issue. For example, when using gray tones for risk classes, the colour white should represent areas with no risk at all. Similarly, with traffic-light colours the colour green should represent safe areas with a negligible or zero risk. When colour ramps are utilized at least the minimum and maximum values of risk should be in the legends. While at national and provincial level risk maps could be presented by continuous values or classes, at municipal and local level the risk of individual objects is required to be visualized.

When the risk has been estimated quantitatively or semi-quantitatively and it is represented by a continuous ramp there are three main options by which these risk values could fit between the minimum and maximum intensity colour: by the standard deviation, by the histogram and by the minimum and maximum values. Figure 7.15 shows the visual effects of some of these options for the same area of a risk index map with the traffic-light representation (i.e. green-yellow-red). The differences in visualization for the same risk values are quite remarkable. In risk maps with classes, similar problems arise since the number of classes and the break values between them should be decided by the researcher.

The use of simple classifications with three classes is preferred for end users such as local authorities. However, for physical planners or other researchers a higher number of classes could be required. For selecting the break values among classes, current GIS systems (the map maker) can select from many methods (e.g. equal intervals, defined intervals, standard deviation and natural breaks).

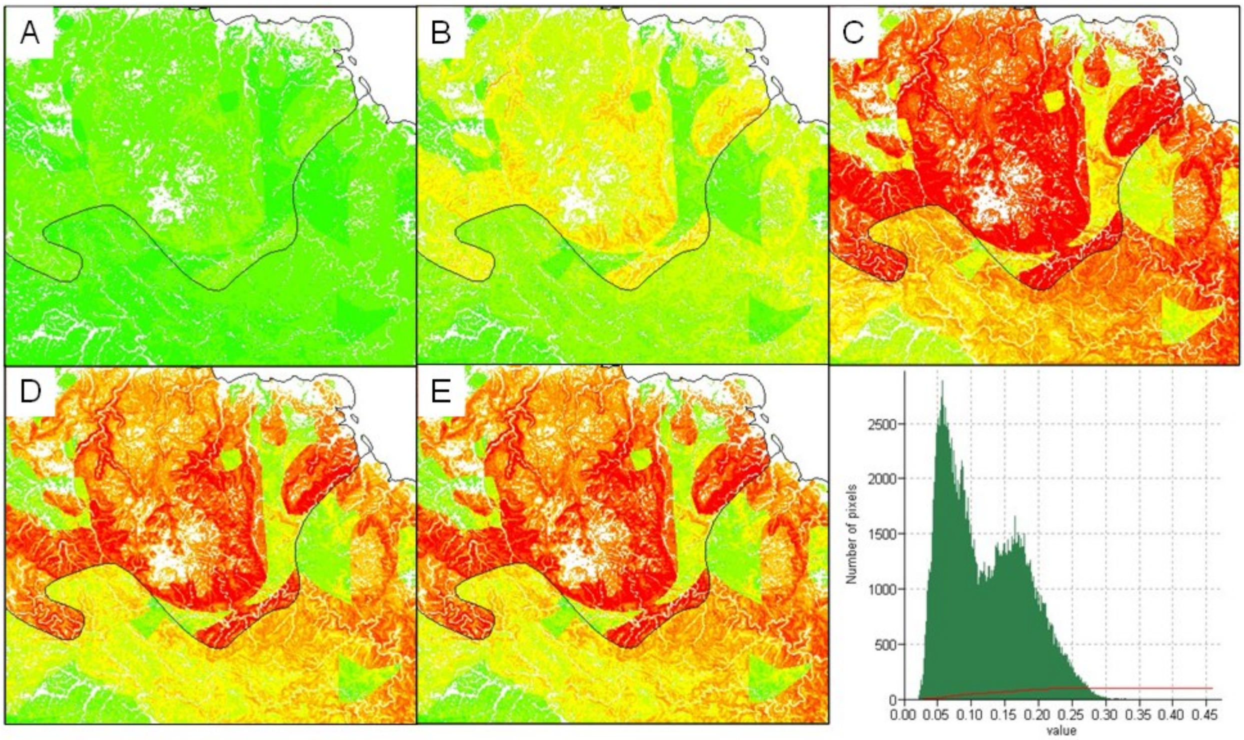


Figure 7.15: Risk representation of the same area with some stretch options and map histogram. A: risk values stretched between 0-1, B: between minimum and maximum risk values, C: between 2 times standard deviation, D: between 0.5 percentage of the histogram and D: between 1 percentage of the histogram (Source: Castellanos, 2008).

Task 7.5: Risk visualization (duration 45 minutes)

The aim of this task is that you use see a number of good examples of visualizations of hazard and risk information. Some examples are:

- http://apps.arcwebservices.com/sc/hurricane_viewer/index.html
  This is the Hurricane Disaster Viewer. You can see current Hurricanes, weather, flood risk maps and many more in this WebGIS application.
- http://www.nola.com/katrina/graphics/flashflood.swf
- This is a so-called Shockwave animation of the events that lead to flooding in New Orleand during Hurricane Katrina.
- http://earthquake.usgs.gov/eqcenter/catalogs/
- http://earthquake.usgs.gov/research/data/google_earth.php
- http://earthquake.usgs.gov/regional/nca/virtualtour/modern.php
  Here you can find a number of examples of Google Earth visualization for earthquakes, and seismic hazard and risk maps for the San Francisco Bay area

WebGIS

Conventional GIS systems include all components of a GIS, such as data management, data analysis or application and data presentation in one single platform, or tier. They have a non-distributable software design, meaning that all components are done on the same system (See Figure 7.16). This makes it difficult to share the results with other users that are located in different places. Therefore in order to be able to visualize and analyze data that are located somewhere else physically, and do that with many different clients, another design is needed. In an Internet based GIS all the individual layers are separated (mulit-tier approach) thus allowing many clients to access and visualize the geo-data at the same time.

The Client is separated from the presentation logic. It offers the possibility to connect different client platforms (PCs,PDAs, mobiles) to the same information system.

A **WebGIS** is a special GIS tool that uses the Internet as a means to access and transmit remote data, conduct analysis, and present GIS results.

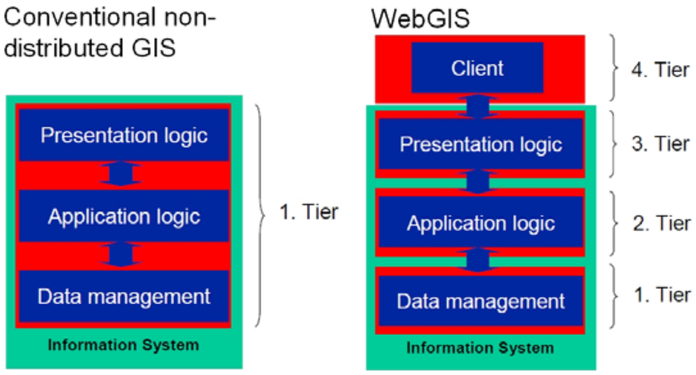


Figure 7.16: A conventional GIS contains all components inside the same system. A WebGIS separates the management, application and presentation part, and makes it accessible to a client. (Source: B. Köbben, ITC).

Several terms are also use: Internet GIs, Distributed GIS, Online GIS, or Networked GIS.
In a WebGIS there is a client – server approach with clients requesting information and servers responding to individual requests.

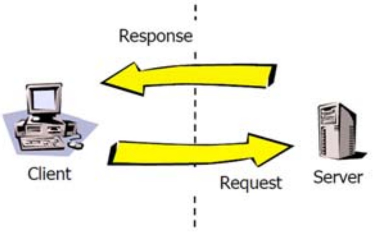


Figure 7.17: Client-Server approach in WebGIS.

In a simple case a client (browser) requests a simple HTML document from a Web-Sever (HTML-server). However in a WebGIS the transferred document is not a simple copy of a previously stored HTML document. Based on the request parameters the output will be dynamically generated as a map. Therefore these systems use other languages , referred to as XML, such as Geographical Markup Language (GML) for geographical data and Scalable Vector Graphics (SVG). The systems should be **interoperable**, meaning that they should be able to transfer data and metadata seamlessly and access functions seamlessly. This requires interfaces and standardization. For WebGIS applications the standardization is done by the Open GeoSpatial Consortium (OGC), a non-profit organization with the aim to deliver spatial interface specifications that are openly available for global use. There are several OGC Webservice specifications such as Web Coverage Service (WCS) focusing on raster data and satellite imagery, and Web Feature Service (WFS) focusing on vector data.
WebGIS has been applied successfully in many countries for the visualization of risk information. Some of the best examples of these are:\

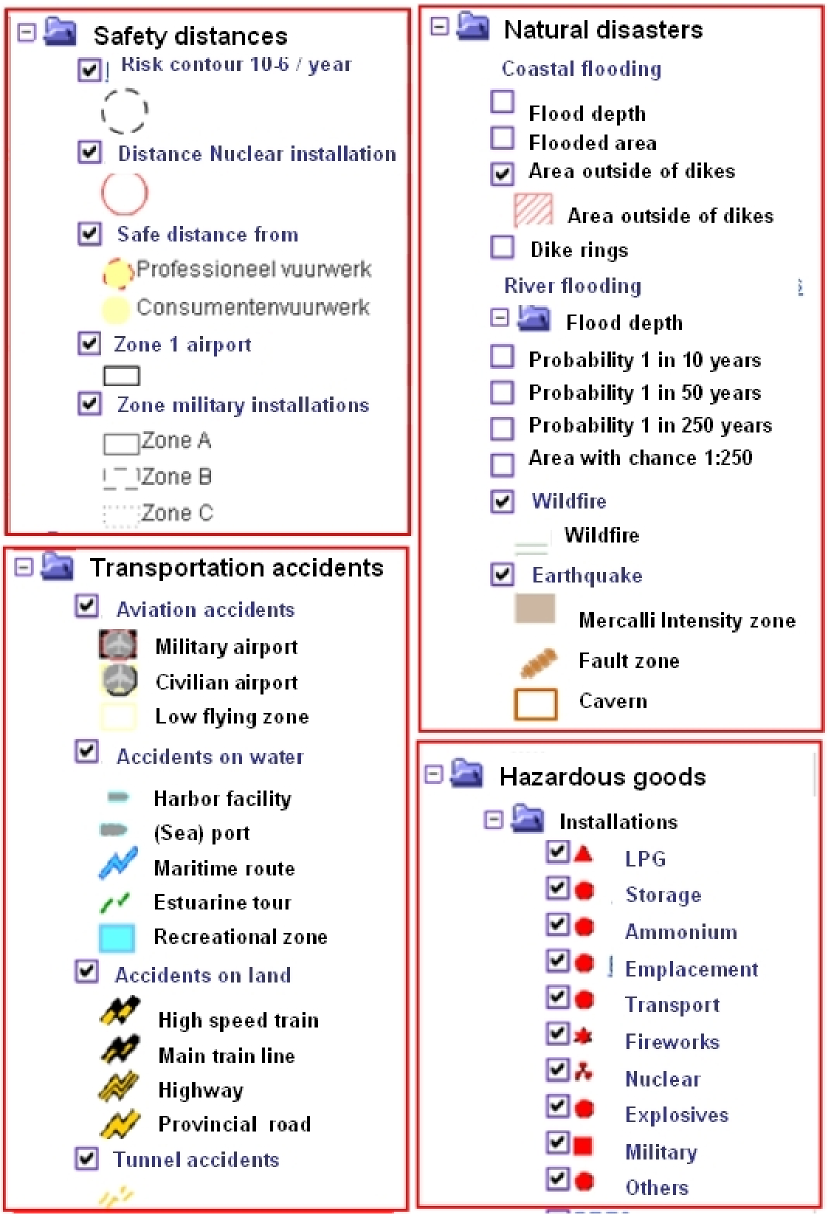
- The Dutch risk map that allows to query multi-hazard risks for the whole of the Netherlands (See also task 7.7)
- The flood risk webGIS application from the UK.

Task 7.6: WebGIS exercise RiskCity (duration 2 hours)

For RiskCity we have also developed a WebGIS application, as mentioned in session 1.3. In this exercise we will use the WebGIS application for a disaster preparedness exercise.

A simplified version of RiskCity dataset is offered. Spatial data are available for different interactions: the user can personally evaluate the type and the resolution of result data archived for every exercise session, compare different kinds of information in a multi hazard-risk assessment, prepare queries according to exercise aims, download information tables for outside elaboration, create his personal layout with new shapes and labels directly drawn on map. WebRiskCity allows the users to learn different levels of risk assessment without actually executing all steps by themselves.

For the exercise descriptions please consult the separate handouts or the blackboard.



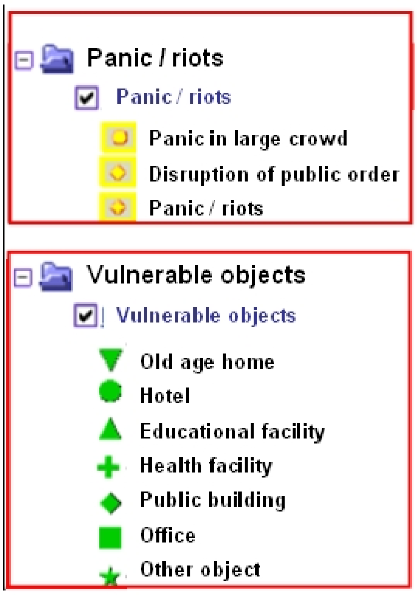


Figure 7.18: Legend of the Dutch national WebGIS risk atlas. www.risicokaart.nl

Task 7.7: WebGIS and risk (duration 30 minutes)

The aim of this task is that you use WebGIS for visualizing risks spatially. We are using the national risk atlas from the Netherlands, which can be accessed through: www.risicokaart.nl

- Click on the Province: **Zuid Holland**. Now the webGIS application will start. Depending on your internet speed this might take some time.
- Select the button for **English** in the upper left corner. Now you can use the legend on the right hand side of your screen to select the items you would like to see.
- Expand the part on **Natural hazards**. Zoom in on the harbour area of Rotterdam.
- Use the information tool to get information on the hazard areas.
- Zoom in further until you are able to expand the **Vulnerable objects**.
- Compare the area with what you can see on Google Earth / Google Maps (e.g. http://maps.google.com/
- What can you conclude on the identification of vulnerable objects on this map?

The Netherlands also has a WebGIS for all areas that are planned to be constructed in the coming decade. This map is accessible through the website: www. www.nieuwekaart.nl

- Click on the map on the left hand side. The interactive map will start.
- Zoom in on the same area that you selected for the risk atlas. You can now check if there are planned developments in high risk zones, by comparing the results of both atlases.

Spatial data infrastructure (SDI)

In session 2 we have discussed how different data types are useful for different disaster types, and at different stages in the disaster management (DM) cycle. From the previous session it has become clear that risk assessment requires a multitude of data, coming from different data sources. In practice it can be a problem to get the appropriate data when needed. Therefore it is important to have a strategy on how to make data available for risk management. Since data is coming from different organizations we have to look at aspects such as data quality, metadata, multi-user databases, etc. Many (supposedly) project-specific data sets can be used for various purposes (e.g. for resource management was well as risk assessment). This requires that the potential users know what data exist, and have ready access to them.

A **spatial data infrastructure** is the foundation or basic framework (e.g. of a system or organization) with policies, resources and structures to make spatial information available to decision makers and the community when they need it, where they need it and in a form where they can use it (almost) immediately.

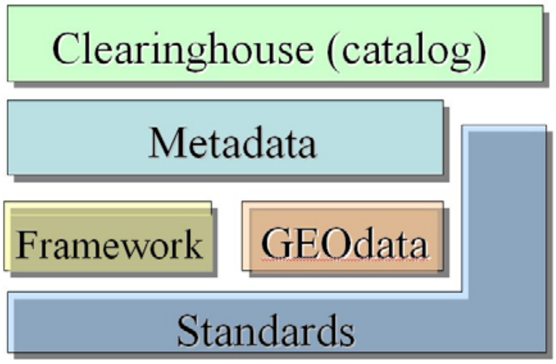


Figure 7.19: Spatial Data Infrastructure

The SDI has the following characteristics: widely available, standardized delivery, easy to use, flexible, multipurpose, taken for granted, public good. An SDI is a system to promote access to and sharing of geodata. It includes the actual Geodata, but also **metadata**, which is a description of the data in terms of producer, contents, scale, quality, format and time of production. The use of data standards is important, in order to be able to share it. But even more so, it is required to have data sharing policies and partnerships to promote and improve the sharing of such data. This in practice is often the largest bottleneck in developing countries where national organizations are often not willing to easily exchange data. SDIs can be implemented at different levels: regional, national and global levels. They support multiple simultaneous users, while allowing limited access to source data (copyright protection). The website where the data is actually exchange is called a **clearinghouse**. In many cases, unfortunately, such data clearinghouses are only established after an disaster event (e.g. following the Indian ocean tsunami or Hurricane Mitch).

Individual SDIs can be linked into a Global Spatial Data Infrastructure (GSDI: http://www.gsdi.org/). You can find examples of SDI's in many different countries. Figure 7.14 shows the clearinghouse of ITC from where images, airphotos and maps can be obtained from all over the world.

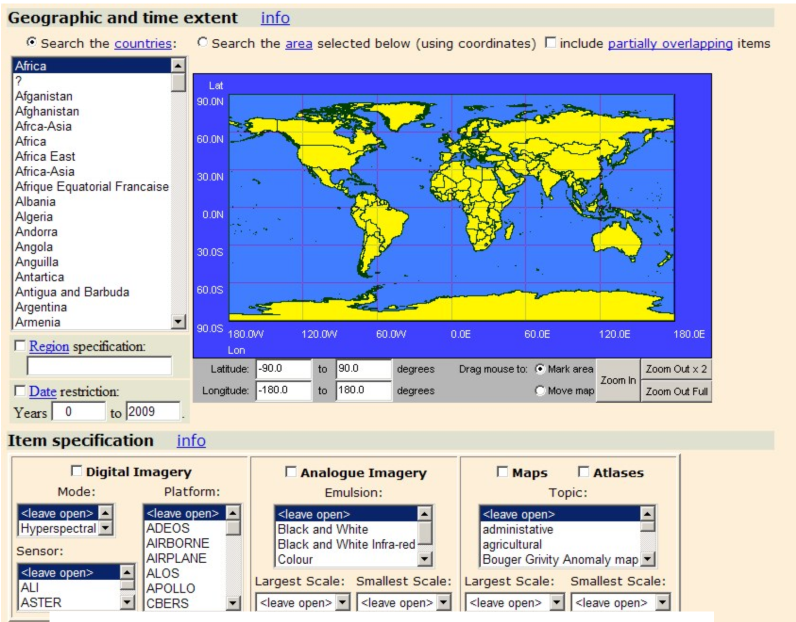


Figure 7.20: ITC's geodata warehouse search page.

Some relevant sites for finding recent disaster data are:

Reliefweb: www.reliefweb.int
Alernet: www.alertnet.org
HEWSweb: www.hewsweb.org
UNOSAT: unosat.web.cern.ch
Intern. Disaster Charter: www.disasterscharter.org
Respond: www.respond-int.org
GDACS: www.gdacs.org

7.5 Risk Reduction (or Mitigation) Options

Risk reduction can be done using different strategies:

- **Risk avoidance**: the aim is to eliminate the risk by modifying the hazard
- **Risk reduction**: to mitigate the risk by modifying the vulnerability to damage and disruption.
- **Risk transfer**: to outsource or insure and modify the financial impact of hazards on individuals and the community.
- **Risk retention**: to accept the risk and budget / save for the expected damages.

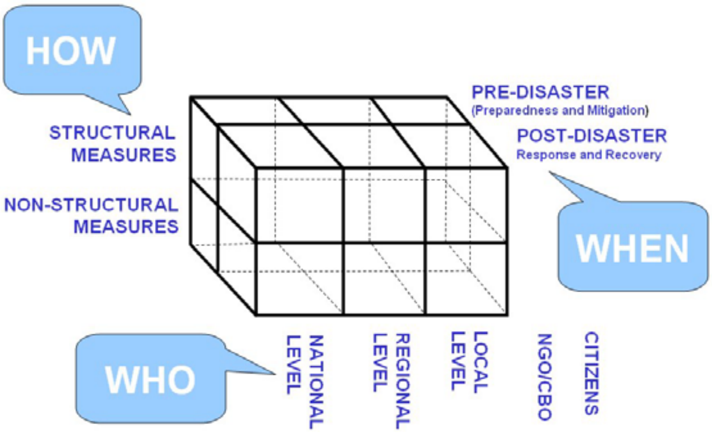


Figure 7.21: Important aspects of disaster risk reduction: how, who and when.

It is important to realize that disaster risk has three main components namely hazards, vulnerability, and amount of elements at risk.

$$\text{Risk} = \text{Hazard} * \text{Vulnerability} * \text{Amount of elements-at-risk} \quad [8.1]$$

This means that risk reduction can be achieved by reduced the hazard, the vulnerability and/or the amount of exposed elements at risk. Risk reduction measures can be grouped in:

Structural measures refer to any physical construction to reduce or avoid possible impacts of hazards, which include engineering measures and construction of hazard-resistant and protective structures and infrastructure. The strategy is to modify or reduce the hazard.

Non-structural measures refer to policies, awareness, knowledge development, public commitment, and methods and operating practices, including participatory mechanisms and the provision of information, which can reduce risk and related impacts. With the aim of modifying the susceptibility of hazard damage and disruption and/or modifying the impact of hazards on individuals and the community.

7.5.1 Structural Measures.

Engineering work can be viewed as either protective or corrective in nature. Of course a cost/benefit analysis has to be done for the engineering works. Often structural measures give a false sense of security, they have a certain design level based on cost benefit analysis or other criteria. If these levels are surpassed there is a residual risk.

A few examples are given here of structural measures for flood hazard reduction (see also Figure 7.19):

- Construction of dams and reservoirs: the return period of the flood in the area downstream of the dam and reservoir are reduced, since the reservoir can accommodate the peak flows.
- Development of controlled /temporary storage of flood water, so-called flood retention basins, which are used to manage storm runoff and to prevent floods and erosion in downstream areas.
- Construction of artificial levees to protect the land at the non-river side from flooding.
- Flood walls (barrier constructed of materials such as masonry block and reinforced concrete). Some designs have openings for access to buildings so they need closures and human presence.
- Channel improvements/ modifications;
- Flood proofing of buildings.

Figure 7.22: Examples of structural mitigation measures. Above: Raised community centre (tsunami hazard), and school retrofitting (earthquake hazard). Middle: raised electrical connection, gabions with vegetation for flood control and floating houses (flood hazard). Below: Retaining walls, slope drainage and biological engineering (landslide hazards)

Some examples of structural measures for landslide risk reduction are:

- Retaining walls that put a load against the toe of the slope to prevent movement
- Anchoring, rock bolting and soil nailing to add strength to rock or soil.
- Galleries to protect transportation lines from rockfall or avalanches.
- Drainage in the slope
- Terracing of slopes

Task 7.8: Structural and non structural mitigation measures (duration 30 minutes)

The aim of this task is that for one type of hazard and consider which structural and non-structural mitigation measures would be suitable.
The assignment has the following steps:

- First make a selection of a type of hazard relevant for your own country. Think about a particular area that has its own type of problems. For instance tsunami risk reduction on the southern coast of Sri Lanka, or volcanic risk reduction around the Merapi volcano in Indonesia. Think about an example yourself.
- Consider different risk reduction options that look at Risk Avoidance, Risk Reduction, and Risk Transfer (see beginning of the section)
- Read also the second part of this section on non-structural mitigation measures
- Make a list of the possible mitigation measures.
- Make a ranking of the mitigation options in terms of feasibility in the area that you consider;
- Explain the ranking and the advantages and disadvantages of the different mitigation options.
- Submit the result of the assignment through blackboard or e-mail.

7.5.2 Non structural Measures

Table 7.6 gives an overview of the main types of non-structural measures.

Table 7.6: Examples of non-structural risk reduction measures(Source: Living with Risk, UN 2004)

Non_structural Measures	Main characteristics / actions
Policy and Planning	Prioritize risk reduction; Incorporation of risk reduction policies into post disaster reconstruction; Integration of risk reduction in development planning and sectorial policies in order to reach the goals of sustainable development, poverty eradication etc.
Legal and regulatory framework	Establishment of legislation and regulatory measures, principally in the field of physical and urban planning, public works rules on land use planning, rules on building codes buildings of special constructions etc.
Organizational structures	Implementation and coordinating bodies; Local Institutions for DRR; Participation of Civil Society, NGO's, private sector, community participation
Resources	Resources mobilization and allocation; Staff allocation; Public Private partnerships
Research	Research programmes into the different aspect of risk and risk reduction; National, regional and international cooperation in research, science and technology development.
Environmental and natural resource management	Combine goals of risk reduction in the management of coastal zones, wetlands, watershed management etc.
Preparedness and contingency planning	The planning of emergency & relief operations. Preparation of operational plans, training of relief groups
Early warning	Monitoring and forecasting; Warning and Dissemination
Emergency management	Management of the disaster situation (effective response); Organizations involved: Civil protection and defence organizations, volunteer networks, NGO.s
Social and economic development practices	Social protection and safety nets; Financial instruments in DRR Sustainable livelihood strategies
Information and communication	Information and dissemination progammes & channels; Public and private information systems ; Networks for DRM
Education and training	Educational policies to include disaster reduction on all educational levels; Vocational training; Dissemination and use of traditional knowledge
Public Awareness	Public Awareness policies and programmes Media involvement in communication risk and awarneness

Legal and regulatory measures

Zoning is used to regulate the activities of the private sector by placing locational restrictions and minimum standards on specific types of land uses and activities.

- **Macro-zoning** is the establishment of land-use planning zones at the national and regional levels. Such zones generally establish agricultural, urban, industrial and recreational uses incorporating existing and future patterns; Specific uses are allowed in designated areas. Macro-zoning has a broad function in risk reduction, since hazardous areas can be zoned permanently for agriculture or recreational uses, minimizing as much as possible urban or semi-urban concentrations of population.
- **Micro-zoning** is the detailed preparation of land use maps by public authorities, fixing specific land uses for each site. Micro zoning is a basic tool which relates natural hazard assessment to land use planning.

Figure 7.23 gives an example of the use of natural hazard maps used in spatial planning in Switzerland, and figure 7.24 an example of the legend used in local zoning maps.

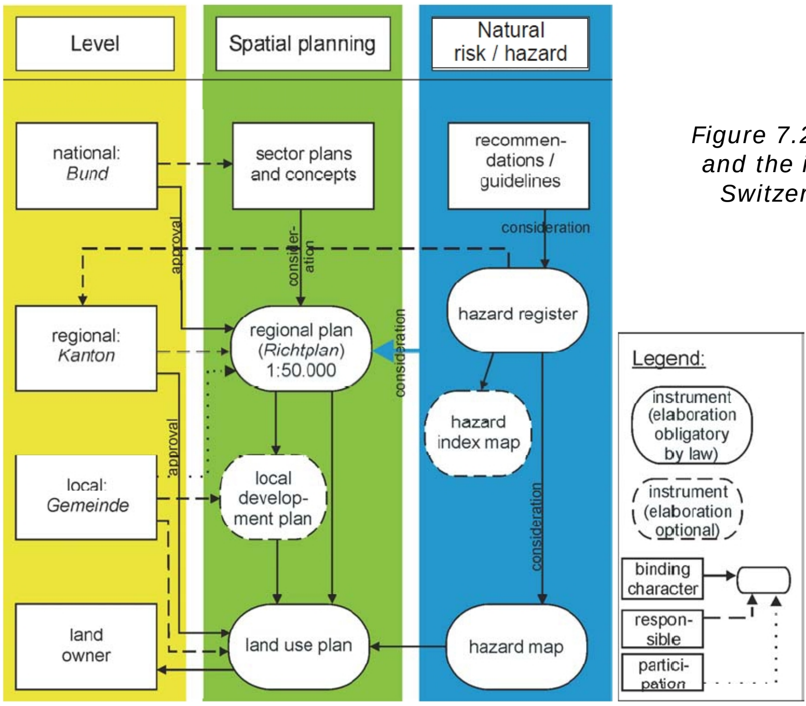


Figure 7.23: Spatial planning system and the integration natural Risks in Switzerland (Source: Darmstadt University 2001)

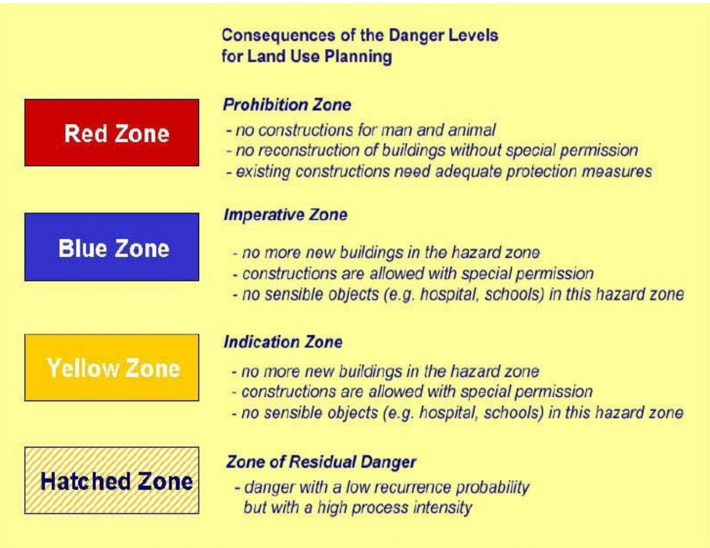


Figure 7.24: Legend of Swiss hazard planning map.

Building codes.

Building codes establish minimum standards of design, construction and materials in order to avoid structural collapse under conditions of severe physical stress caused by extreme natural phenomena. Building codes are used for earthquake, flood, wind, and landslide hazard reduction. The co-ordination of land-use controls and building codes is one of the most effective local level devices for disaster prevention and mitigation;

Standards for the repair or rehabilitation of older structures could serve as a supplementary means of improving the safety of existing structures.

Retrofitting:

Retrofitting is the modification of existing buildings to protect them (or their content) from damaging events, such as earthquakes.

Development and redevelopment policies

These include:

- Design & location of services and utilities;
- Redevelopment and renewal;
- Land-right acquisition:

- Permanent evacuation; e.g. Public land acquisition to withhold land for development for prevention measures.
- Open-space use / control: agricultural lands, parks and other types of open spaces can play an important role in helping mitigate the effect of natural disasters. Open spaces may serve to prevent or mitigate disasters while providing some economic return.

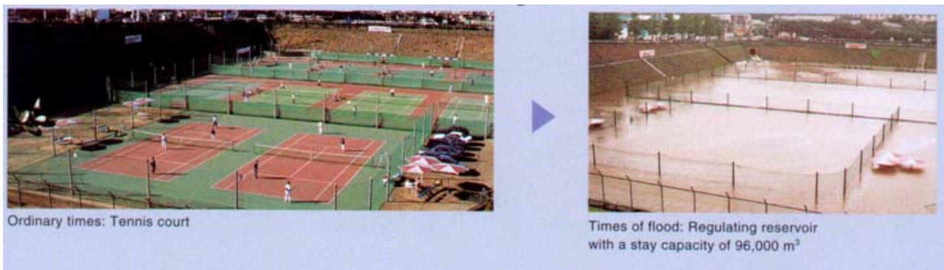


Figure 7.25: Use of the same area for two purposes during normal and flood periods (Source: Rivers and Japan no15/2000)

Construction or location permits
A construction permit can be used not only to regulate the type of land-use activity and the structure it occupies but also to enable the authorities to control employment opportunities thereby influencing patterns of development.

Organizational structures e.g Community-Based DRR.

Recognizing that disasters happen at the local level, risk reduction strategies must be built on sustainable community-based development plans. This allows reducing vulnerabilities and strengthens people's capacity to cope with hazards. In the text box below Community based disaster risk management is explained.

Preparedness and contingency planning

Actions designed to minimize loss of life and damage, and to organize and facilitate timely and effective rescue, relief and rehabilitation in cases of disaster. (i.e. the planning of emergency / relief operations).
It includes:

- Forecasting and warning / monitoring
- Education and training of the population
- Organization for and management of disasters situations,
- Preparation of operational plans, training of relief groups,
- Stock piling of supplies
- Earmarking of necessary funds

Major components of disaster preparedness are: organization, emergency operations, communications, evacuations, disaster warnings.

Task 7.9: RiskCity exercise: disaster preparedness planning (duration 3 hours)

The aim of this exercise is that you use the risk information that you have generated in the previous exercises for emergency preparedness. We will make a simulation of an emergency that might take place in RiskCity. You work in a team as the geo-information department of the local authority and you have to provide the local authority with the required information to respond to the emergency.
This exercise is done in real time, so you have to indicate to the course coordinator when you want to start with the exercise. You will then receive e-mails from technical institutions and from the RiskCity Emergency Preparedness Center, requesting for information. In a period of 3 hours you have to provide the correct answers to their requests and mail them back to the course coordinators.

‘Community-based disaster risk management (CBDRM)

Community-based disaster risk management (CBDRM) is a process in which at-risk communities are actively engaged in assessment of the community's hazard exposure and analysis of their vulnerabilities as well as capacities and this forms the basis for activities, projects and programs to reduce disaster risks. The community should be involved in the process of assessment, planning and implementation. (http://www.adpc.net/PDR-SEA/publications/12Handbk.pdf)

This means that people are at the heart of decision making and implementation of disaster risk management activities. The involvement of most vulnerable social groups is considered as paramount in this process, while the support of the least vulnerable groups to them is necessary for successful implementation.

CBDRM emerged as an alternative during the 1980s and 1990s. Over the past two decades it has become apparent that top-down approaches fail to address the needs of vulnerable communities, often ignoring local capacities and resources.

The top-down approach can increase vulnerabilities and undermine the quality of life, security and resiliency. The CBDRM approach emphasizes the active involvement of communities in al phases of risk management.

CBDRM is built upon the following principles (Source: Kafle) :

- CBDRM contributes to addressing the root causes of vulnerabilities and transforming the structures that generate inequality and underdevelopment;
- CBDRM is a development approach. Recognizing the need for community action for disaster risk reduction in all development practice;
- Any efforts to reduce disaster risks should build upon a community's knowledge and experience about hazards, vulnerabilities and disaster risk reduction. It will also be essential to recognize the importance of local customs, culture and materials while developing and implementing risk reduction programs.
- CBDRM requires a high level of coordination and cooperation amongst stakeholders e.g. among Government departments, NGOs, donors, vulnerable groups;
- CBDRM advocates and workers believe that they are accountable to the people first and foremost;
- There is a need to maintain efforts to enhance inclusiveness, decentralization and empowerment.

Processes of CBDRM

The main goal of CBDRM is to transform at-risk communities to disaster resilient communities. The general process of CBDRM is as follows (Victoria 2002 in Kafle, ADPC):

- Rapport building with community;
- Community profiling;
- Community risk assessment;
- Formulation of initial disaster risk reduction plan;
- Formation of community disaster response organization;
- Community-managed Implementation of reduction measures;
- Participatory Monitoring and evaluation.

CBDRM aims at achieving disaster risk reduction, sustainable development and poverty reduction, people empowerment and equity. CBDRM is envisioned as an integral component of sustainable development, since it helps in avoiding the negative impacts of disasters on development (ADPC 2004).

Key Actors

In the CBDRM processes the following stakeholders are considered as a key to make it effective and sustainable:

- Vulnerable groups and persons;
- Multiple social groups in a community;
- Outside agencies- Government Departments including local governments, NGOs, civil society groups, Media, donors and UN.

Early warning

Early warning systems are intended for the provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazards to take action to avoid or reduce their risk and prepare for effective response.

Early warning systems include the following components:

- Understanding, and mapping the hazard;
- Monitoring and forecasting impending events ;
- Processing and disseminating understandable warnings to political authorities and the population, and
- Undertaking appropriate and timely actions in response to the warnings

Remote Sensing can offer very good possibilities in monitoring hazard events. Different satellite systems are available with different spectral (both optical and microwave), spatial and temporal resolutions. Monitoring is centered on the collection of diagnostic parameters of the hazard and tries to detect the onset of the hazard event. Different hazards need different monitoring systems. Besides there is the scale of monitoring and constraints can technological, economic, financial, social or environmental. In figure 7.26 an example is given of monitoring of floods in the Camarque using ERS_SAR (radar) imagery.

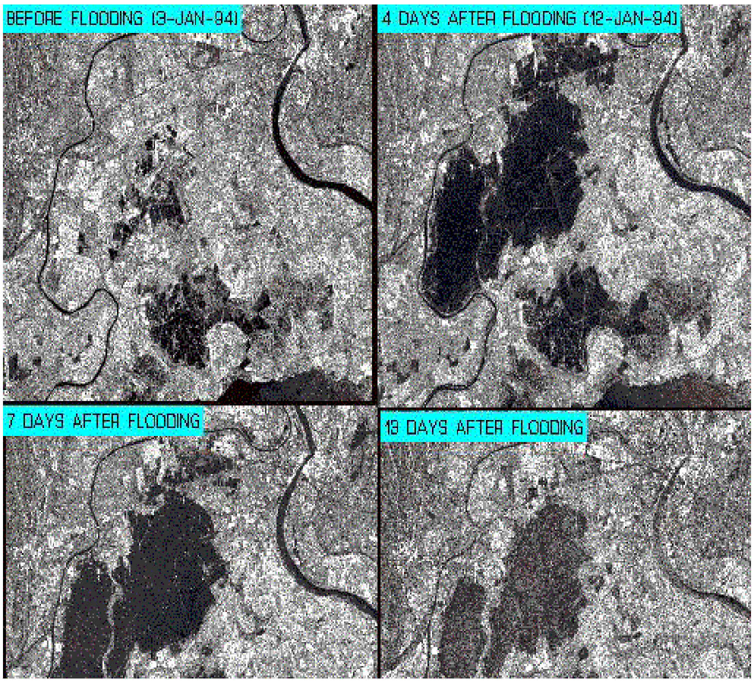


Figure 7.26: Monitoring flooding using radar imagery.

Forecasting relates to a scientific evaluation of an real time hazard event, leading to a general alert about hazardous conditions, and a warning contains additional information, including recommendations for action.

Technological developments have increased the availability, reliability and accuracy of short-term disaster warnings, particularly in cases of tropical storms, wild fires, high rainfall, floods, volcanic eruptions, tsunamis and crop damage (e.g., frost, locust plague, and drought). Ideally, warnings should be given sufficiently far in advance of the event to enable protection of both life and property. But the scale of the effort and time required to protect property is such that, in the present state of knowledge, warnings of (some) impending disasters can in most cases only be given in time to permit saving of life and perhaps the most valuable (or cherished) property. To be effective, warnings must have a very low false alarm rate. However, in slow-breaking disasters such as drought where assessment of the developing situation may be possible, food stockpiles and transportation infrastructure can (in theory, at least) be built up and/or steps can be taken to encourage people and animals to move to areas where more reliable water supplies may be found.

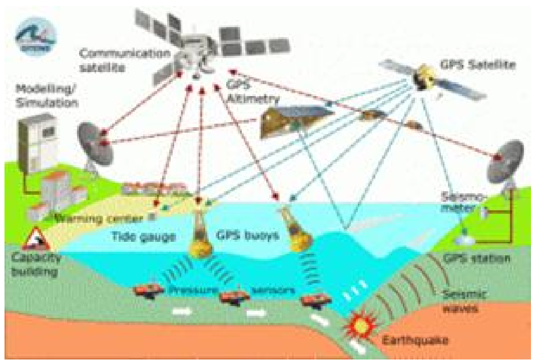


Figure 7.27: Set-up of the tsunami early warning system

Five stages of forecasting /prediction and warning can be differentiated:

- Technological forecasting (by the scientific community)
- Scientific evaluation;
- Decision-making (to warn or not warn);
- Communications; (e.g. by radio/visual signals/sound signals)
- Public response.

For fast-breaking phenomena, there may be little time for the message to get out to the population; the delivery system, therefore, must be fast and reliable. It must permit the message to reach people directly and in such a manner that it is convincing because of a tendency to discount the validity of a warning or reluctance to part from home or other psychological factors. In order to improve the level and effectiveness of response to such warnings, education programmes including material on the warning systems themselves, should be carried out among the vulnerable population and their active participation should be sought.

Emergency management

This refers to the organization and management of resources and responsibilities for dealing with all aspects of emergencies, in particularly preparedness, response and rehabilitation. Emergency Management relates to short term measures to be taken to respond to particular disaster situations. It involves plans, structures and arrangements established to engage the normal endeavors of government, voluntary and private agencies in a comprehensive and coordinated way to respond to the whole spectrum of emergency needs.

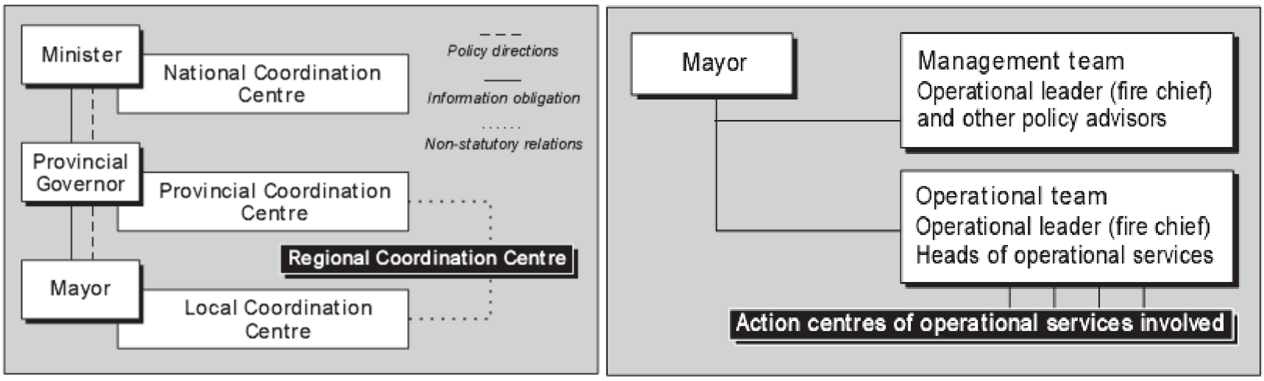


Figure 7.28: Structure of the Dutch Disaster Management organization. The Mayor plays a central role at the local level (Source: Bezuyen et al., 1997).

Social and economic development practices

In order to encourage the proper, rational development of land, governments may wish to provide fiscal and financial incentives, including subsidies and loans to land owners who comply with urban and land-use regulations designed to reduce disaster risks.
In addition to obtaining desirable development patterns, tax measures may be used to discourage development in areas where open spaces are needed for both low density uses and/or hazard mitigating measures. Governments may settle for higher tax yields rather than prevent settlement on disaster risk land.
Negative land taxation:

- Land taxation can have more than one purpose and more than one effect.
- Reduce land speculation,;
- Increase the rate of development on unimproved land,
- Land taxes designed to discourage development on high risk land may simply encourage more intensive development;

Positive land taxation:

- Various kinds of grants or low interest loans for building, or for the purchase of building materials in order to avoid building in high risk zones.
- The subsidies would have to be sufficient initially to outweigh other economic incentives or benefits of living in high risk zones.

Both insurance and mortgage policies can be used to encourage the public to adhere to zoning regulations and building codes specifically designed for disaster prevention and mitigation purposes.
Insurance is a key loss-sharing strategy. Through the payment of an annual premium , the policy holder is able to spread the costs of the disaster over a number of years. Insurance can be either commercial or state insurance. Not in every country it is possible for people to insure for natural hazards. Insurance companies may be persuaded to offer reduced premiums for buildings that incorporate hazard resistant structures. Other risk spreading instruments are: calamity funds, catastrophe bonds, micro-credit and finance.

Education, training and public awareness

Educational policy can be used to create awareness of hazards and the risks caused by the hazards, what can be done both by the public and the emergency authorities to prepare for the impact and reduce its effects; and what can be done after a disaster.

Education on disaster risk and risk reduction can be given at all levels of education. It is a long term goal. Community training programmes can be developed and carried out. It is also of importance in education and training to ensure that the public will, in time of need, react intelligently and promptly to warnings, and comply with them and with instructions issued by the emergency authorities. Education for disaster reduction is a transdisciplinary exercise aimed at developing knowledge, skills and values which will empower people of all ages, at all levels, to assume responsibility for building a safer and sustainable future (UNESCO). Activities can be training for disaster preparedness, earthquake drills, flood evacuation, participation in community based hazard mapping vulnerability mapping etc.

Figure 7.29: Example of awareness raising: Earthquake safety day in Kathmandu, Nepal (Source: NSET, Nepal)

Public Awareness relates to the processes of informing the general population, increasing levels of consciousness about risks and how people can act to reduce their exposure to hazards. Awareness campaigns try to educate the population a try bring about a change in behaviour leading towards a culture of risk reduction. This can be done by broadcasts on radio and television, items in the newspapers, organizing counseling/ meetings and the establishment of information centers and networks, and community and participation actions (after UNISDR, 2004)

Criteria for evaluating mitigation strategies.

Strategies and measures for risk reduction must be evaluated against a series of criteria (economic, technical, social, financial and environmental criteria) to allow the selection of the most desirable. The **final choice of strategies is political** and will eventually depend on the weight placed on safety by elected officials as **compared with** the emphasis given to **other goals** that the society is also attempting to achieve, such as **economic growth, improved health etc.**

Table 7.7: Criteria for evaluating mitigation options.

Criteria	Strategy-Related Questions
Equity	Do those responsible for creating the hazard pay for its reduction? Where there is no man-made cause, is the cost of response fairly distributed?
Sustainable	Does the risk reduction measure contribute to sustainable development?
Poverty reduction	Does the risk reduction measure contribute to poverty alleviation?
Timing	Will the beneficial effects of this strategy be quickly realized?
Leverage	Will the application of this strategy lead to further risk reducing actions by others?
Cost to government	Is this strategy the most cost-effective or could the same result be achieved more cheaply by others?
Administrative efficiency	Can it be easily administered or will its application be neglected because of difficulty of administration or lack or expertise?
Continuity of effects	Will the effects of the application of this strategy be continuous or merely short term?
Compatibility	How compatible is this strategy with others that may be adopted?
Jurisdictional Authority	Does this level of government have the legislated authority to apply this strategy?
Effect on economy	What will be the economic impact of this strategy?
Effects on environment	What will be the environmental impacts of this strategy?
Hazard creation	Will this strategy itself introduce new risks?
Hazard reduction potential	What proportion of the losses due to this hazard will this strategy prevent? Will it allow the safety goal to be reached?
Public and pressure group reaction	Are there likely to be adverse reactions to implementation?
Individual freedom	Does the strategy deny basic rights?

7.6 Cost-benefit analysis for disaster reduction measures

There are a number of tools that can be used in evaluating the best scenarios for disaster risk reduction:

- **Cost Benefit Analysis** is used to compare costs and benefits of a project over a period of time in monetary terms;
- **Cost Effectiveness Analysis**: (CEA) has most of the features of CBA, but does not require the monetization of either the benefits or the costs (usually the benefits). CEA does not show whether the benefits outweigh the costs, but shows which alternative has the lowest costs (with the same level of benefits).
- **Multi Criteria Analysis** (MCE) is a tool that, in contrast to CBA, allows the treatment of more than one criterion and does not require the monetization of all the impacts. MCE results in a ranking of alternatives.
- The growing importance of environmental and social issues has led to the emergence of instruments such as **Environmental Impact Assessment** (EIA) and Social Impact Assessment (SIA). The output of these instruments could be presented separately or linked to the outcome of a CBA.

According to the ISDR conceptual framework, disaster risk reduction must be placed in the broader context of sustainable development, where economic, socio-cultural, environmental and political factors/goals are to be considered. Many angles have to be studied. One can use the tools of cost benefit analysis to assess the economic and financial acceptance of risk reduction measures, but it is preferred to use to CBA in conjunction with other decision support methods, such as such as cost-efficiency or multi-criteria analysis.

In order to justify public investments in risk reduction for a certain hazard we need to assess all costs and benefits associated with this risk reduction. Besides, we need to know how large the current risk is in terms of damage per year in order to compare with other types of hazards and to compare to other societal goals.

In disaster risk management the benefits are mostly the avoided or reduced potential damages and losses. For instance in a flood control project the benefits can be reduced potential flood damages and a higher income /value of the land were the land is protected.

The reduced damages can either be direct or indirect damages or monetary (tangible) or non_monetary (intangible) (See session 6.2).

The aim is to reduce the risk, thus to decrease the area under the probability-loss curve. A schematic example is given in figure 7.30. Figure 7.30a shows the original situation with the annualized risk being the area under the red curve (the blue area). In figure 7.30b for a possible risk reduction measure (e.g a flood protection scheme protecting for floods up to the 100 yr recurrence interval) the new risk curve is indicated as the green curve. The new risk is indicated by the blue + orange area. The risk reduction is indicated with the yellow area. As long as the yellow area is not larger than the orange area the risk is reduced. How much and how the probability loss curve is shifted depends very much on the type of risk reduction measure.

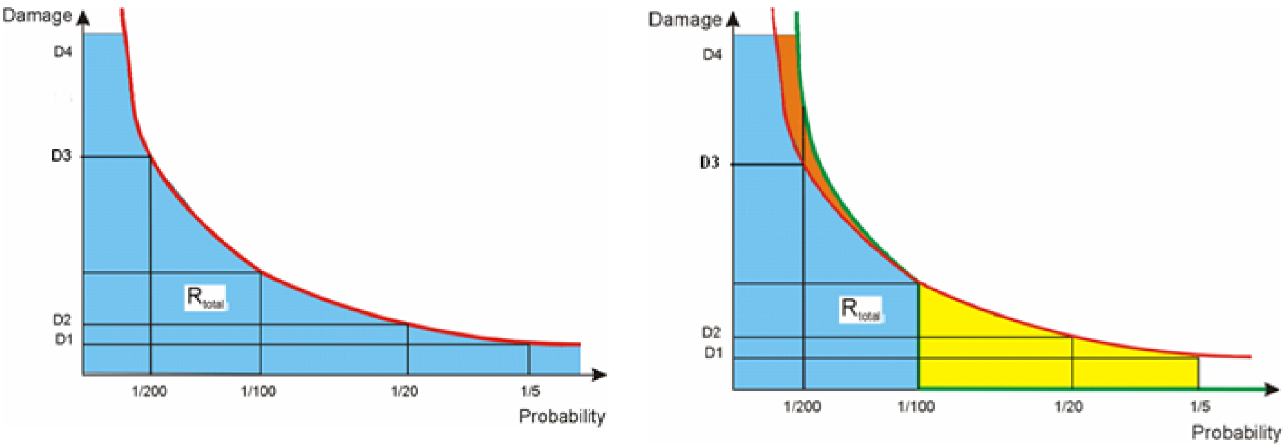


Figure 7.30: a: The amount of risk is, in the original situation, is the blue area under the red probability-damage curve. B: A risk reduction option is applied: the new amount of risk is the blue area + the orange area. The yellow area is the reduction in risk due to the risk reduction measure.

Cost Benefit Analysis as a tool for decision making.

Cost-Benefit Analysis (CBA) is a tool used in public decision-making and consists of a set of procedures for defining and comparing benefits and costs. The tool assists in identifying, measuring and valuing in monetary terms the benefits and costs of a project.

Resources such as capital, land, labour and management capacity are relatively scarce and can be allocated by a nation / agency/ person to different uses. What choice is made depends among others on the benefits that the specific allocation creates as compared to the costs of the project; you want to know whether a "project "is worthwhile and whether it is the best alternative.

Public agencies and development organisations will be particularly concerned with the question of whether a proposed project is a good investment in terms of its contribution to the welfare of society. CBA is an instrument that will assist in answering this question

CBA as applied in public decision-making typically takes the perspective of the society and is often referred to as the *economic* analysis or the economic CBA. This analysis is often complemented by a *financial* analysis of the project. The financial analysis compares the costs and benefits from the perspective of the project organisation or a specific target group (see text box below). If the CBA is extended to include aspects of income distribution, one speaks of *social CBA*.

Economic versus Financial appraisal.

Financial appraisal:

- Works with actual prices paid on the market;
- Perspective: private (single person or firm) ;
- Focuses on the actual financial burden.

Economic (or social) appraisal;

- Reflects the value of costs and benefits for the national economy as a whole , including impacts on intangible goods and services.
- Economic evaluation is the appropriate one to apply if calculations of hazard damage are to be designed for supporting public policy decisions.
- Economic appraisal attaches fictive prices to production factors (land, capital , labour) indicating the scarcity in the national economy;
- Maximize national income
- These fictive prices are called accounting prices, economic prices, social prices or shadow prices.
- Shadow prices are usually used for unskilled labour, taxed or subsidized consumer goods, and foreign exchange, interest.

CBA is one element in the overall appraisal (including technical, social, environmental, legal and institutional issues) of a project. CBA contributes to narrowing the margin for pure judgement in the decision-making on proposed projects. The output of a CBA might be a recommendation on the acceptance or rejection of a project, or the identification of bad project components, which could lead to adjustments in the project design (Dopheide, 2003).

In both economic and financial analysis, cost and benefits are assessed in the situation with- and without the project. Cost and benefits have their own 'autonomous" development if no project is carried out (see figure)

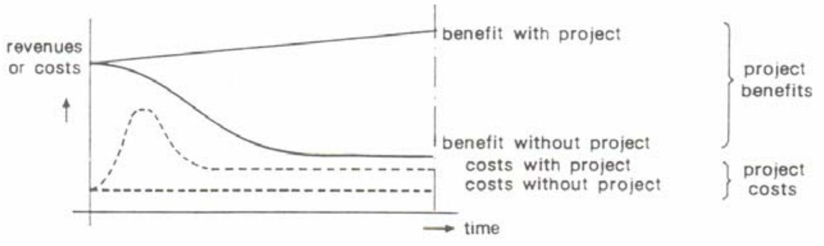


Figure 7.31: Benefits with and without the project

- Project benefits are benefits with the project minus the benefits without the project.;
- Project costs are the costs with the project minus the costs without the project.

Discounting.

Costs and Benefits occur in different amounts and at different time periods during the project, so in order to compare these costs and benefits, both costs and benefits have to be discounted (against a certain interest rate). Since money today is worth more than money in the future . Example: Two financial concepts;

- If a person lends money to another person, he is entitled to some kind of reward. This reward is called interest.
- A certain sum of money today, earning interests from year to year will grow to become a larger sum of money in the future depending on the rate of interest; this is called **compounding**. Conversely, a certain sum of money at some time in the future is equivalent to a smaller sum of money today, depending on the interest rate.; this is called **discounting**.

Compounding: What an initial amount of money becomes when growing at compounding interest.
Compounding: from present to future;

Compounding formula:

$$X_t = X_0 (1 + i)t$$

X_0 = present value
X_t = value in year t

Example 1:
Suppose an amount of € 100 (X_0)on a bank account;
Interest rate =10%
Calculate the amount after 1 year (=X_1), after 2 years (=X_2) and 3 after (=X_3) years ?

$X_1 = 100(1 + 0.1)^t = 100(1.1)^1$= €110
$X_2 = 100 (1+ 0.1)^2 = 100 (1.1)^2 = 100* 1.21$ = €121
$X_3 = 100 (1+ 0.1)^3 = 100 (1.1)^3 = 100*1.331$ = €133.1

Discounting: What is the present value of a known future amount , or How much a known future amount of money is worth today.
Discounting: Present value = Future value * discount factor.

Discounting formula:

$$X_0 = X_t / (1 + i)t \quad \text{or} \quad PV = FV * 1/ (1 + i)t$$

X_0 = present value — PV = present value
X_t = value in year t — FV = future value

Example 2:
What is the present value of €133.1 received at the end of year 3 from now, assuming an interest rate of 10%.

$$X_0 = X_t / (1 + 0.1)3 = 133.1 / (1+ 0.1)^3 = 133.1 / 1.331 = 100$$

Basic CBA steps (Dopheide,2003):

1. Define scope of the project: public/private, time horizon, physical boundaries of the study
2. Identify the type of costs and benefits (See table 7.8)
3. Put monetary values on costs and benefits. Special care should be taken with inflation. Usually cost and benefits are considered without taking inflation into consideration
4. Compare costs and benefits. Organize costs and benefits over time.
5. Calculate profitability indicators/decision criteria
6. Sensitivity analysis
7. Make recommendations

In table 7.8 an overview is given showing costs and benefits occurring in different years and the resulting incremental benefits or cash flow.

Table 7.8: Example of organizing costs and benefits in time.

Year	0	1	2	3	4
Investment	500				
Recurrent costs (e.g. maintenance)		50	50	50	50
Benefits		200	200	200	200
Net incremental benefits or Cash flow	-500	150	150	150	150

Calculate profitability indicators/decision criteria.

Net Present Value (NPV): The NPV is the sum of the discounted net incremental benefits of a project at a prevailing discount rate**.** For financial appraisal the commercial bank rate is usually taken.

$$NPV = \sum_{i=1}^{n} \frac{values_i}{(1+rate)^i}$$

Values = series of net incremental benefits;
i = discount rate

The NPV is an indication of the feasibility of the project. In both financial and economic analysis the NPV should always be positive to make the project acceptable.

Table 7.9: Example of calculation of NPV.

Year	0	1	2	3	4
Investment	500				
Recurrent costs (e.g. maintenance)		50	50	50	50
Benefits		200	200	200	200
Net incremental benefits or Cash flow	-500	150	150	150	150
Present value at 10 % interest rate	-500	136	124	113	102
NPV	-25				

Internal Rate of Return (IRR): Is that discount / interest rate at which the discounted costs equal the discounted benefits i.e the NPP = zero. It represents the average earning power of the money used in the project. This indicator is used by most financing agencies in cases where projects are not mutually exclusive.

There are financial IRR's and economical IRR's. Whenever the IRR is higher than the opportunity cost of capital or the external discount rates offered at the bank the project is economically or financially feasible . When two projects are mutually exclusive, that means that the implementation of project A excludes the implementation of project B, the NPV is the required indicator for comparison of projects.

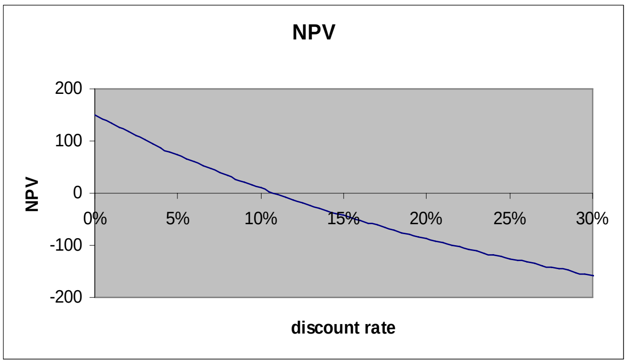


Figure 7.32: Plotting NPV at different discount rates

Example: When the choice is between project A with an NPV = 400, and project B with an NPV = 2000, project B is chosen. The IRR can be calculated in by plotting the NPV at different discount rates.

Benefit-Cost Ratio (BCR): The benefit / cost ratio is defined as the ratio between the discounted incremental benefits and the discounted incremental costs, calculated at current commercial or accounting discount rates. This indicator should be higher than 1 for a project to be acceptable. If projects are to be compared which are not mutually exclusive, the IRR is a better indicator than the B/C ratio, because IRR is independent of external discount rates and independent of the way associated costs are dealt with. The BCR is rarely used because different classifications of costs lead to different outcomes.

Net benefit-investment ratio (N/K ratio). The net benefit-investment ratio gives more consistent results than the BCR as a clear distinction is being made between investment costs and costs made after the investment. The N/K ratio gives the ratio of the present value of the net benefits and the investment at a prevailing discount rate. Net benefits are given by the net incremental benefits in the years where the net incremental benefits are positive, whereas the investment is given by the incremental net benefits in those years that the net incremental benefits are negative.

Table 7.10: CBA decision criteria

Indicator	**Decision**	
	Accept	**Reject**
NPV	NPV > 0	NPV < 0
IRR	IRR > discount rate	IRR < discount rate
BCR	BCR > 1	BCR < 1
N/K ratio	N/K > 1	N/K < 1

Uncertainty, assumptions and sensitivity analysis:
In this step the elements that are most uncertain or risky are identified and the the assumptions made during the analysis are indicated. Sensitivity analysis is applied to relevant parameters in order to obtain an indication of the robustness of the assumptions made. These parameters could include costs, benefits, prices and the timing of costs and benefits; Calculate the switching values on the most relevant parameters.

Final recommendations

- Formulate a final recommendation based on the results of the economic and financial CBA.
- An unambiguous conclusion on the profitability of a project is formulated if the economic and financial CBA have the same result (e.g. economic and financial NPV are both positive or both negative).
- If a project is economically unfeasible but financially sound, the project should not be supported on economic grounds but might be attractive for the private sector to implement.
- If the project is economically sound but financially unfeasible, a solution might have to be recommended for the weak financial basis that might prove a risk to the sustainability of the project.
- -Structure the recommendation within a context by making special reference to the effects that could not be monetised, to the assumptions, and to the uncertainty and gaps in knowledge.

Cost-Benefit Analysis and Inflation
Net present value calculations provide a valuable theoretical approach for handling financial and economic analyses. One practical issue that often raises questions concerns the treatment of *inflation* in cost-benefit analyses. Inflation refers to a general increase in prices throughout the economy. *Inflation should be separated from and not be confounded with the time value of money*. Common practice in cost-benefit analysis is to express all cash flows in constant or real prices as if there is zero inflation. This is valid as long as it is reasonable to assume that prices of all inputs and outputs change in a same degree. Moreover, setting up the cash flow in nominal prices (rather than constant or real prices) requires an inflation forecast, which is a difficult if not impossible task. There are no economic tools that allow us to forecast inflation as far into the future as required for the life of a typical project. Therefore it is preferable to use constant or real prices for cash

flows in financial and economic CBA. This implies that a real interest or discount rate (I.e. corrected for inflation) has to be applied.

Limitations:
It is preferred to use to CBA in conjunction with other decision support methods, such as such as cost-efficiency or multi-criteria analysis . This is because CBA has its limitations e.g. the “distributional issue” that CBA does not address the distribution of benefits and costs. Societal welfare is maximized by simply aggregating individual welfare over all people affected and changes therein due to projects and policies. A focus on maximizing welfare, rather than optimizing its distribution is a consequence (Dasgupta and Pearce, 1978 in Mechler, 2008) .

Task 7.10: RiskCity exercise: Cost benefit analysis for risk reduction measures (duration 3 hours)

After calculating the expected losses for the different return periods, and the average annual risk,in the exercises of session 6, we would now like to analyze the various options that the municipality has to mitigate the risk, using a basic cost/benefit analysis. Go to the description of this exercise in the exercise book and follow the instructions.

7.7 SEA for risk assessment and management

Strategic Environmental Assessment (SEA) is an iterative decision support tool that helps planners and decision-makers to assess the environmental, social and economic impacts of proposed **Policy, Plan or Programme (PPP)** initiatives and its alternatives at the **earliest** possible stage of decision-making. SEA is now in many countries an integral part of the development of large scale plans, programmes or strategies, and may include national or local risk management policies or plans.

Risk assessment and management is a process of identifying and evaluating the adverse risks associated with natural and/or human induced hazards and developing strategies to manage it (7.1). The following stages are usually taken in the decision making process:

1. Risk management objectives
2. Establish decision-making criteria
3. Assess the risk
4. Identify options/measures
5. Assessment of options/measures
6. Make decision and prepare plan
7. Implement Plan
8. Monitor

The SEA approach seeks to identify key environmental, social and economic issues, define SEA objectives and appraisal criteria and promote a sustainable plan process. The SEA process usually comprises six main stages, which are linked to the plan stages. Stakeholder participation and involvement are an essential part of the SEA and should be undertaken throughout the different stages of the SEA and plan process (see figure 1 below).

If, through ***screening***, the need for an SEA of the proposed risk management policy or plan is established, ***scoping*** starts. The scoping stage sets the framework for the SEA. The key environmental, social and economic issues are identified and a set of SEA objectives and targets developed. The purpose of SEA is also to determine the extent and level of detail to be included in the SEA, as well as the collection of baseline information. An important aspect of SEA is the consideration and assessment of alternatives or options. Developing and comparing alternatives allows the decision-maker to determine how to achieve the strategic action's objectives at the lowest (social/environmental/economic) cost and greatest benefit The same people who propose the strategic action and objectives should define options. In section 7.5 different risk reducing options were described. However, if no or insufficient options are considered by the initiator, the SEA team can assist in the development of options and help identify the preferred alternative, and ensure that this is as sustainable as possible. Clearly, the assessment of alternatives should be carried as early as possible in the planning process.

The ***assessment*** stage of the SEA will involve the identification and assessment of likely significant effects of the identified risk management options using the SEA objectives to inform the choice of one or more preferred option(s). First avoidance of negative effects and enhancement of beneficial effects should be taken into account. Then, if effects cannot be avoided, mitigation measures are considered and finally compensation measures. The results of the assessment are brought together in an SEA report. This report is reviewed based on a set of review criteria and through stakeholder consultation, after which a decision is made to approve the SEA, or ask for further amendments.

The last stage requires the monitoring of the impacts of risk management plan during and after its implementation.

Risk assessment and development planning

Risk assessment may also be used as a tool and input in (an SEA for) other development plans or projects. If, for example, there is a plan to establish a new waste disposal site, areas prone to natural or human risk should be avoided. A simple way of identifying areas that would be inappropriate - and appropriate - for development is to superimpose maps of areas of constraint, in this case areas prone to risk. As part of the assessment a vulnerability analysis can be carried out using (weighted) overlay techniques.

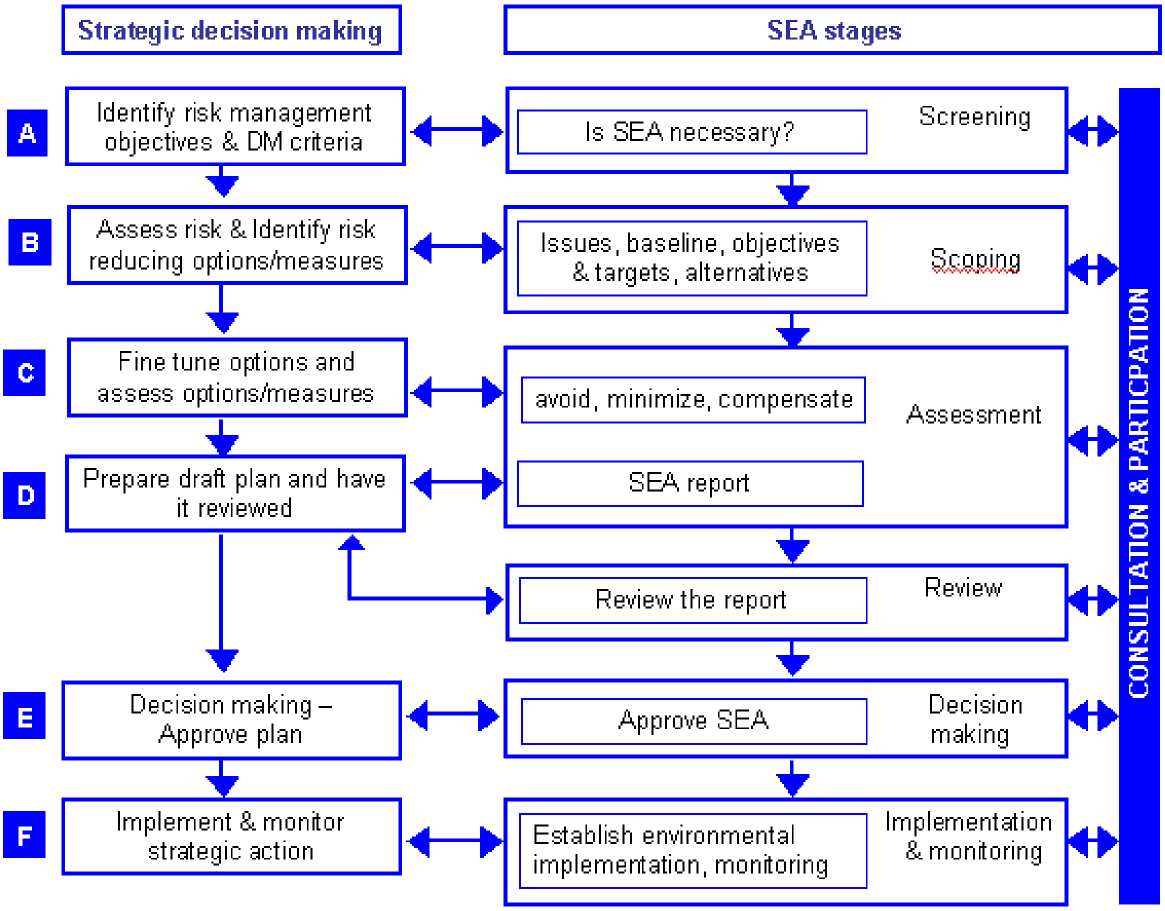


Figure 7.33. Integration of SEA in Decision-making for Risk Management.

Selftest

In order to evaluate whether you have understood the concepts that were presented in this session. Please make the following test, and check the answers in Blackboard.

Question: Disaster risk management
Hazard and risk maps are used in the following phase of disaster risk management:
A) Disaster prevention.
B) Disaster preparedness.
C) Disaster response.
D) All of the above.

Question: Risk Visualization
Google Earth can be very helpful as a visualization tool in disaster risk assessment, because it can:
A) Help you to map the areas affected by a disaster immediately after a disaster has occurred.
B) Allows you to generate Digital Elevation Models of your study area that can be used in hazard assessment
C) Helps to map elements at risk from high resolution images if they are available for a particular area.
D) Allows you to monitor hazard events while they are happening.

Question: Disaster risk reduction measures
Examples of non-structural flood risk reduction measures are:
A) Insurance and reinforcement of buildings
B) Dikes and evacuation planning
C) Early warning system and land use zoning
D) Elevated buildings and awareness raising

Question: Cost-benefit analysis
In the economic cost benefit analysis for a particular risk reduction measure the following component(s) is/are important:
A) Investment costs
B) Period of investments
C) Risk reduction obtained
D) All of the above

Question: Risk reduction
An example of a structural risk reduction method for a flood hazard is
A) Early warning system
B) land use planning.
C) a levee
D) a cellar

Question: cost benefit analysis
The construction of a flood retention basin is subject to a cost-benefit analysis. The final analysis gives at a discount rate of 12% a Net Present Value of minus € 1,500.
This implies that the Internal Rate of Return (IRR) is:
A) most probably negative (below 0%)
B) most probably between 0 and 12%
C) exactly 12%
D) most probably higher than 12%

Further reading:

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Reinhard Mechler (IIASA) &The Risk to Resilience Study Team; 10/2008. http://www.provention consortium.org/?pageid=37&publicationid=158#158

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